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The FIFA 11+ injury prevention program in amateur futsal players: effects on performance, neuromuscular function and injury prevention.

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Dissertação apresentada às provas para a obtenção do grau de Doutor em Fisioterapia, nos termos do Decreto-Lei 74/2006 de 24 de março de 2006, orientada pelo Professor Doutor Fernando Manuel Tavares da Silva Ribeiro e coorientada pelo Professor Doutor José Manuel Fernandes Oliveira e Professor Doutor Rui Jorge Dias Costa.

Porto 2018

Lopes, M. (2018). *The FIFA 11+ injury prevention program in amateur futsal players: effects on performance, neuromuscular function and injury prevention.* Doctorate dissertation in Physiotherapy, presented at the Faculty of Sport, University of Porto.

KEY-WORDS: WARM-UP, ADULTS, NEUROMUSCULAR TRAINING, NEUROMUSCULAR PARAMETERS, SHORT AND LONG-TERM EFFECTS.

Dedication

I dedicate this research to my dearest and so loved children, Lucas and Clara and to my wife, Maira, who were always by my side, who accompanied, inspired, supported and understood me during this long journey. There are no words to describe here how much I value all the support you gave me.

I will be forever thankful!

In memory of my dear and beloved grandmother, who accompanied me from a distance, but always so close to me.

Thank you for everything you gave me!

Acknowledgements

I thank all those who have always been with me on this long journey.

Firstly my doctoral advisor, Professor Fernando Ribeiro, for sharing with me his immense knowledge, for his friendship, encouragement and constant and dedicated monitoring from the first to the last day. To my co-advisors, Professor José Oliveira and Professor Rui Costa for the insightful comments and incentive during the development of the work. I would also like to thank the Director of the Doctoral Degree in Physiotherapy for guidance on the preparation of the PhD project. My gratitude goes to everyone who scientifically made this work possible.

I would also like to thank everyone who has collaborated in the various research development processes. Mário Rodrigues, for the essential support in the extensive process of data collection, to Daniela Simões and Fábio Araújo for the essential support in the statistical treatment of data. To my sister, Susana Lopes, Pedro Monteiro, Telma Patinha, Jéssica Ferreira, Filipa Martins, Mauro Ferreira, Miguel Gomes, Joaquim and others who participated in the processes of this research project. Thank you so much! Tour help was essential to see this work through!

I will never forget the main elements that validated this research project. The athletes, the coaches, the directors and other personnel, essential in the course of this process, my thanks!

A special thanks to two important people in the decision making of the direction to take for this journey, Professor António Amaro and Professor Francisco Amado. Thank you!

Hoping that I did not forget anyone at this stage of acknowledgements, I would like to express my special gratitude to Mr. Norberto Rei for his flawless accompaniment during the intense process of fieldwork, having accompanied me every day… I really mean every day, during the entire sports season! A real fellow, a true friend!

To Conceição Graça, my colleague in the first Doctoral Program in Physiotherapy of the Faculty of Sport of the University of Porto, my friend, my big thank you for your company, for your friendship and for your support. I hope to be able to return at least everything you gave me, so that you can also accomplish your journey.

To the Faculty of Sport of the University of Porto, to the School of Health Sciences of the University of Aveiro, what a privilege to take part in their amazing laboratory and research facilities!

To my parents, for my education and constant support. To my remaining family, thank you! I will never forget your support!

Thank you, God, for lighting my path, for blessing me, for providing this opportunity and granting me the capability to proceed successfully.

To all who have been and are always by my side ... I thank you!

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RESUMO

O rápido crescimento nas taxas de participação no futsal e consequentes questões associadas às lesões decorrentes da sua prática tem aumentando a consciencialização e a preocupação de todos os envolvidos na modalidade, pois estimou-se que a taxa de lesões no futsal é o dobro do futebol. O principal objetivo deste estudo foi examinar o efeito do FIFA 11+ na redução de lesões em jogadores amadores de futsal, bem como avaliar os efeitos a curto e longo prazo em parâmetros neuromusculares e de performance física.

Setenta e um jogadores de futsal de seis clubes amadores foram recrutados e randomizados para o grupo FIFA 11+ (n=37, idade: 27,0 ± 5,1 anos) ou um grupo controlo (n=34, idade: 26,0 ± 5,1 anos). O grupo de intervenção foi submetido a 10 semanas de FIFA 11+, 2 sessões/semana, seguido por um período de 10 semanas de *follow-up*. Durante o período de *follow-up* ambos os grupos realizaram apenas aquecimento regular durante as sessões de treino. Os parâmetros de performance e neuromusculares foram avaliados com recurso a testes de agilidade (*T-Test*), sprint (30m), flexibilidade (senta e alcança), salto vertical (*squat jump*), equilíbrio estático (unipodal) e dinâmico (*Y-balance*), proprioceção (sensação de reposicionamento articular ativo), força muscular (isocinética) e tempo de latência dos eversores. Foram avaliados antes, após o FIFA 11+ e após 10 semanas de *follow-up*; os dados de lesão foram recolhidos durante a época desportiva.

Os resultados não mostraram melhorias na performance ou nos parâmetros neuromusculares após a intervenção, porém após 10 semanas de *follow-up*, observaram-se melhorias significativas na força excêntrica tal como no rácios isquiotibiais/quadricípite para o membro dominante. O grupo FIFA 11+ apresentou redução significativa do número total de lesões, tal como das lesões agudas, lesões do membro inferior e das lesões sofridas nos treinos. O presente estudo demonstrou que o FIFA 11+ reduz significativamente as lesões em jogadores amadores de futsal. As melhorias significativas obtidas para os efeitos a longo prazo do FIFA 11+, indiciam a necessidade de aprofundar este tema de investigação de forma a compreender os fatores envolvidos no efeito preventivo de lesão deste programa.

PALAVRAS-CHAVE: AQUECIMENTO, ADULTOS, TREINO NEUROMUSCULAR, PARÂMETROS NEUROMUSCULARES, EFEITOS A CURTO E LONGO PRAZO.

ABSTRACT

The fast growth in the rates of futsal participation is increasing the awareness and concern regarding the public health significance of futsal injuries as it is estimated that the rate of injuries in futsal is the double of football. The purpose of this study was to examine the effectiveness of the FIFA 11+ in reducing injury in amateur futsal players, as well as assess the short and long-term effects on performance and neuromuscular parameters.

Seventy-one male futsal players from six amateur clubs were recruited and randomized to an intervention (n=37, age: 27.0±5.1 years) or a control group (n=34, age: 26.0±5.1 years). The intervention group was submitted to 10 weeks of FIFA 11+, 2 sessions/week, followed by a 10-week follow-up period. During the follow-up period both groups performed only regular warm-ups during their training sessions. Physical performance and neuromuscular parameters were assessed by measuring agility (T-test), sprint (30m), flexibility (sit-and-reach) vertical jump performance (squat jump), static (single legged postural sway) and dynamic balance (Y-balance), proprioception (active joint position sense), strength (isokinetic), latency of the everter muscles, along with injury data during the sport season. The results did not show enhancements after intervention in performance or neuromuscular parameters, however after 10 weeks of the termination of the FIFA 11+ program the players revealed improvement in eccentric strength for both lower limbs as for the hamstring to quadriceps ratios for the dominant limb. The FIFA 11+ group demonstrated a significant reduction of overall, acute and lower limb injuries, as for injuries sustained during training sessions. The present study demonstrated that the FIFA 11+ is an injury prevention program suited for injury reduction in amateur futsal players. The significant enhancements obtained for the long-term effects of the FIFA 11+, leads to need for further investigation to identify the underlying factors of the injury prevention effects in futsal players.

KEY-WORDS: WARM-UP, ADULTS, NEUROMUSCULAR TRAINING, NEUROMUSCULAR PARAMETERS, SHORT AND LONG-TERM EFFECTS.

List of Abbreviations

FIFA	Fédération Internationale de Football Association
HRmax	Maximum heart rate
CI	Confidence interval
F-MARC	Medical Assessment and Research Centre
PEP	Prevent Injury and Enhance Performance Program
ACL	Anterior cruciate ligament
RR	Rate ratio
MVC	Maximal voluntary contraction
RFD	Rate of force development
SEBT	Star excursion balance test
RCT	Randomized controlled trial
IG	Intervention group
CG	Control group
M	Months
RCF	Regular coach focused
CPF	Comprehensive player focused
UCG	Unsupervised control group
AE	Athletic exposure
H	Hamstring
Q	Quadriceps
H/Q	Hamstring to quadriceps
Conv	Conventional
Funct	Functional
N/A	Not applicable
JPS	Joint position sense
USA	United States of America
SD	Standard deviation
β	Beta
NWP	New warm-up program

SPSS	Statistical package for the social sciences
Q60con	Concentric peak torque of the quadriceps at 60°/s of angular velocity
H60con	Concentric peak torque of the hamstrings at 60°/s of angular velocity
Q240con	Concentric peak torque of the quadriceps at 240°/s of angular velocity
H30ecc	Eccentric peak torque of the hamstrings at 30°/s of angular velocity
ECOSEP	European College of Sports and Exercise Physicians
EMG	Electromyography
sEMG	Surface electromyography
CoP	Centre of pressure

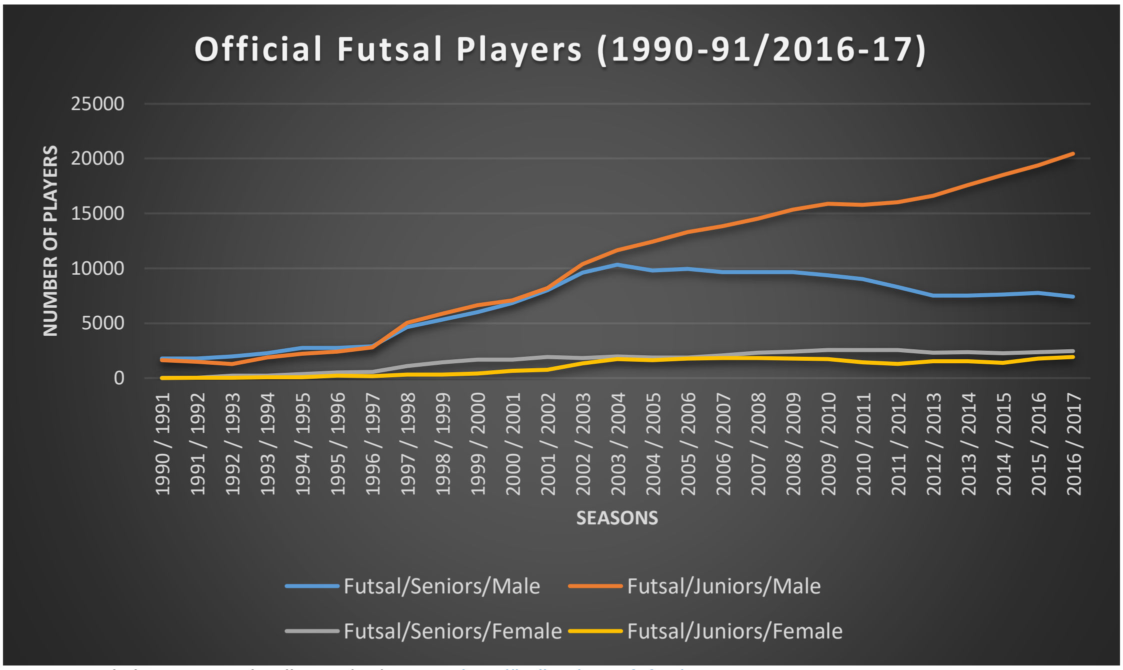
CHAPTER 1

INTRODUCTION

Futsal: the specificities of the World's fastest growing indoor sport.

Futsal as we know it is a quite recent team sport, but its origins go back as far as 1930, when a physical education teacher in Montevideo, Uruguay, invented this new form of football (Moore et al. 2014; FIFA 2015). Juan Carlos Ceriani intended to develop a type of football that could be played in any kind of weather conditions and in restricted spaces (FIFA 2015; Barbero-Alvarez et al. 2008). The Fédération Internationale de Football Association (FIFA) regulated the sport and registered the official version as '5-a-side' to establish a framework to grant its development worldwide (Moore et al. 2014). In fact, futsal is considered to be the World's fastest growing indoor sport (Berdejo-del-fresno 2014). It is estimated to have over 30 million players worldwide (FIFA 2015) being Portugal one of the countries were the popularity of this sport has grown well (Berdejo-del-fresno 2014). Interestingly, a recent FIFA study has shown that nowadays futsal is played not only indoors, but also outdoors in over 170 out of 2009 FIFA members associations (FIFA 2015) and it is played at amateur, semi-professional and professional level (Moore et al. 2014).

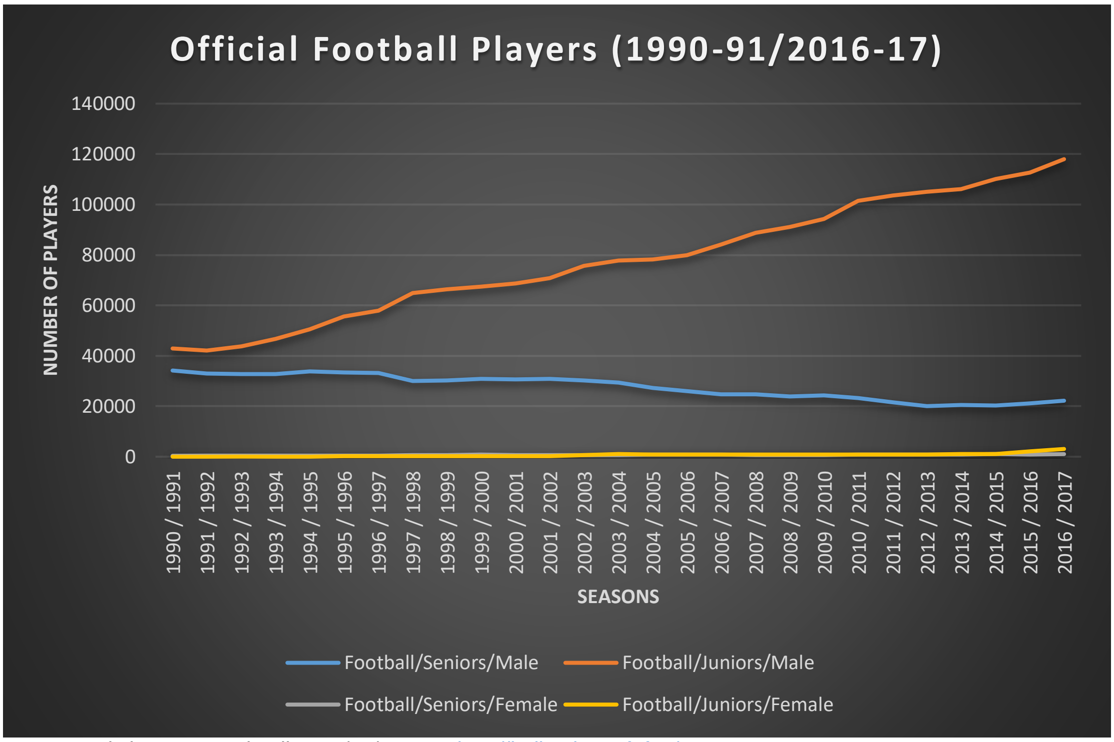
Portugal maintains records of federated players since 1990-91 (Figure 1). In fact, the evolution of the numbers of futsal players since 1990 has greatly increased, with impressive continuous growth of junior players. For senior male players, the growth suffered a cut back since 2003. If we take a look at the numbers of federated football players (Figure 2), which contemplate larger numbers compared to futsal, the senior male players are decreasing since the beginning of the accessed statistics (1990/91). No record was found concerning the dropping numbers of senior players, however, again we may observe the remarkable growth of junior players.



Source: Statistics accessed online 06/07/2017 at http://indicadores.fpf.pt/.

Figure1. Official Futsal Players 1990-91/2016-17 (Seniors and juniors, male and female).

Futsal is played by five players, in which one is a goalkeeper, on a field court with average range dimensions of 40 by 20 meters, with goals of 3 by 2 meters. The game permits unlimited substitutions out of the seven possible substitutes, during the 20 minute halves. The allotted game time is effective playing time, as the clock is stopped in multiple rule-related situations (Barbero-Alvarez et al. 2008; Berdejo-del-fresno 2014; Beato et al. 2016). Being a multiple-sprints sport, futsal implies more high-intensity phases than football, in terms of proportion of match time (Barbero-Alvarez et al. 2008). The unlimited substitutions may be a reason why players maintain a high intensity of activity during the entire game (Medina et al. 2002). The fast movements with sudden changes of direction, the need for quick decisions in a tight space makes the game attractive to more and more players, as well as can be of use as a complement for training in 11-a-side football teams (FIFA 2015). Futsal may be similar to football in certain aspects, however its specific characteristics make futsal a game in its own right, deliberated as an excellent player development tool (FIFA 2015; Moore et al. 2014; Barbero-Alvarez et al. 2008).



Source: Statistics accessed online 06/07/2017 at http://indicadores.fpf.pt/.

Figure2. Official Football Players 1990-91/2016-17 (Seniors and juniors, male and female).

Conceivably, due to the apparent similarities, several studies have compared football and futsal players in diversified parameters as in anthropometrics, performance, and others. A study by Milanovic et al. enrolling a sample of 40 futsal players and 42 football players from the first Croatian futsal and football league, found no differences in anthropometric measures between football and futsal players (Milanovic et al. 2011); possibly based on the fact that the majority of futsal players start as football players, making the transition later on (Jovanovic et al. 2011; Milanovic et al. 2011). On the contrary, Burdukiewicz et al., found significant differences between 22 university futsal players and 22 professional football players, referring that futsal players presented quite a few anthropometric differences. They were found to be lighter, shorter, had shorter lower limbs, narrower hips, and lesser hip circumference and bone breadth values, and curiously, higher levels of body fat and endomorphy. Concerning performance, no differences were found in agility, concluding that players in similar levels may share the same level of agility performance (Burdukiewicz et al. 2014). On the other hand, Benvenuti et al. established significant differences in favour of female futsal players of the regional level Italian league, with enhanced results in the field reactive visual stimuli agility test, as well as in decision-making time, comparing to female football players (Benvenuti et al. 2010). Reiteratively, in another study involving 70 female Turkish futsal and football players, female university futsal players revealed superior performance characteristics regarding agility and speed (10, 20, 30m sprint tests) comparing to female players in the 1st League of Football (Ünveren 2015).

A brief review that compared futsal, beach football and football matches, distinguishes the higher intensity of the games of futsal and beach football, especially of beach football. Accordingly, futsal and beach football requires higher anaerobic capacity and muscle strength than football (Leite 2016). A study that profiled a one-month training load in male and female football and futsal players, revealed that futsal training is more intense comparing to football, targeting a maximum heart rate (HRmax) between 60 and 90%, during approximately 75% of training time. In the other hand, football showed lower intensity results reaching between 50 and 80% of HRmax, during 65% of training time (Clemente & Nikolaidis 2016). A large cross-sectional study that compared aerobic capacity between professional football (n=367) and futsal players (n=186), revealed that football players had better aerobic performance that futsal players (Baroni et al. 2011).

The small quantity of studies published so far, to our best knowledge, do not provide definite evidence about the performance differences or similarities between the two modalities. Additionally, the assessment protocols were also diversified, making comparison more challenging. Considering futsal may have similarities to football, it seems that there may be some performance specificities.

As could be expected, different competition levels may present differences in performance. In a study that enrolled 8 Australian National Team players and 10 State League Team players over 4 futsal matches, the overall distance covered by elite futsal players revealed to be greater than the distance covered by sub elite players. The difference was sustained to the higher average match-play speed and the extended game period (Dogramaci et al. 2011). In another study with elite (n=15) and sub-elite (n=14) female futsal players, which assessed physical performance parameters, no differences were found in active and passive straight leg raise tests, concentric extensor and flexor muscle strength of the knee at 60º/s of angular velocity, jumping performance (squat and countermovement jumps), 30m sprint and in repeated sprint ability test. However, significant differences were found in 30m agility, and maximum ball speed during shooting (Ramos-Campo et al. 2016). Naser and Ali, tested 24 New Zealand male futsal players of three different levels (elite: n=8; sub-elite: n=8; social: n=8). The players were submitted to physical and skill related tests. The time, the shot speed taken, and the points scored per shot in the Massey Futsal Shooting Test were significantly superior for elite comparative to social players. The Loughborough Football Passing Test performance was significantly better in elite players in comparison to social players. Distance covered in the Futsal Intermittent Endurance Test was significantly greater in elite relative to semi-elite and social groups. However, no significant differences were found between groups in jumping performance (countermovement jump). Relatively to sprint performance, elite players were faster in the 5m sprint than both semi-elite and social futsal players, and faster than the social players through 10 and 20m sprint. In this study, elite players showed superior shooting and passing skills as well as greater sprinting and intermittent-running ability (Naser & Ali 2016).

In summary, futsal is a fast-growing sport regarding the number of participants, sharing similarities with football however revealing its own specificities. This sport seems to involve more high-intensity phases in terms of proportion of match time when compared to football (Barbero-Alvarez et al. 2008), however the small quantity of studies published, do not provide clear performance differences or similarities between the two modalities. Nonetheless, performance differences are clearer comparing different level of sports participation.

Futsal: incidence and characteristics of injuries

The distinct components of futsal like the repetitive cycles of single-leg standing while dominating or protecting the ball from the opponents, may entail stress on the joints of the lower leg, predisposing the foot and ankle to injury (Cain et al. 2007). Junge and Dvorak analysed injuries during three consecutive Futsal World Cups (2000, 2004, 2008), and revealed that futsal tends to fewer contact and foul play injuries compared to football; however, the location and type of injuries showed similarities in the futsal and football (Junge & Dvorak 2010). On average in the three tournaments, the study revealed an incidence of 1.30 injuries per match (95% CI 1.10 to 1.50), 195.6 injuries per 1000 player hours (95% CI 165.8 to 225.6) or 130.4 injuries per 1000 player matches (95% CI 110.5 to 150.3). Most injuries were caused by contact with another player. The injuries affected the lower extremity (n=115; 69.7%) most frequently, followed by head and neck (n=21, 12.7%), upper extremity (n=17; 10.3%) and trunk (n=12; 7.3%). The body parts predominantly injured were knee (n=26; 15.8%), thigh (n=23; 13.9%), ankle and lower leg (each n=20; 12.1%). Most injuries were diagnosed as contusions (n=73; 44.2%), sprains or ligament ruptures (n=32; 19.4%) and strains or muscle fibre ruptures (n=29; 17.6%) (Junge & Dvorak 2010). A previous study by Ribeiro et al., implemented during the 15th Brazilian Futsal Sub20 Team Selection Championship, revealed an incidence of 1.39 injuries per game, in a total of 23 games (Ribeiro et al. 2006). The injuries with contact were predominant, with a 65.62% rate (21 out of 32 injuries), and the major part of these injuries did not result in removal of athletes from the sportive activities, implying a percentage of 65.62% rate of injuries without time-loss. Most injuries were sprains (28.12%) and contusions (31.25%), affecting primarily the lower limb (84.37%). The rate of injuries resulting in game or training removal was 0.48 injury/game, or 71.7 injuries/1000 player match hours (Ribeiro et al. 2006).

The ankle sprain, as well for groin and thigh strains, are the most prevalent diagnoses when it comes to time-loss injuries in futsal, with an equivalent percentage of 11.9% (Junge & Dvorak 2010). In another study, the authors also identified ankle sprains as the most prevalent injury with a percentage of 48.8% of all injuries (Serrano et al. 2013); however, the study used retrospective data and the athletes were enquired for "*the three main injuries found during the sports career in futsal*", which inevitability, may have left out other less significant injuries. A previous study by Cain et al., also observed that 32% of the futsal players enrolled (n=76), sustained at least one ankle/foot injury during the season (Cain et al. 2007).

In short, the available evidence suggests that most injuries are not time-loss injuries. Regarding time-loss injuries, the main injuries sustained by futsal players are contusions, sprains (namely ankle sprains), and strains, especially groin and thigh strains. There is need for better understanding on the incidence, characteristics and causes of futsal injuries at all playing levels so that specific programs to prevent injuries may be developed for this sport (Junge & Dvorak 2010).

Injury prevention programs

Injuries affect in a negative form the athlete as well as in the team's performance. Naturally, injury prevention is an issue that has drawn a considerable amount of attention in sports. Generally, studies have approached the issues of prevention of lower limb injuries from the most diverse points of view, like in foot orthoses (Larsen et al. 2002; Franklyn-Miller et al. 2011; Withnall et al. 2006; Bonanno et al. 2015), external orthoses (McGuine et al. 2012; Frey et al. 2013), balance training (McGuine & Keene 2006; Emery et al. 2007; Emery et al. 2005; Mohammadi 2007; Hupperets et al. 2009), stretching (Ekstrand & Gillquist 1983; Pope et al. 1998; Pope et al. 2000; Hartig & Henderson 1999; Cross & Worrell 1999), strength training (Askling et al. 2003; Gabbe et al. 2006; Petersen et al. 2011; Zouita et al. 2016; Van der Horst et al. 2015) and multi-intervention programs, with (Olsen et al. 2005; Eils et al. 2010; Emery & Meeuwisse 2010) and without specific equipment (Mandelbaum et al. 2005; Steffen et al. 2008; Soligard et al. 2008). To our best knowledge, none of these studies included futsal players. However, within the topic of the injury prevention programs, not all studies have presented the desired injury prevention outcomes (Steffen et al. 2008; Van Beijsterveldt et al. 2012; Gatterer et al. 2012; Hammes et al. 2015). Nevertheless, the majority of the studies support the use of injury prevention programs to reduce injury rates (Ekstrand et al. 1983; Mandelbaum et al. 2005; Soligard et al. 2008; Gilchrist et al. 2008; Pasanen et al. 2008; Emery & Meeuwisse 2010; Junge et al. 2011; Mohammadi 2007; Ekstrand et al. 2011; Waldén et al. 2012; Steffen et al. 2013; Grooms et al. 2013; Bollars et al. 2014; Owoeye et al. 2014; Silvers-Granelli et al. 2015; Van der Horst et al. 2015; Van

Der Horst et al. 2013; Rössler et al. 2016; Soligard et al. 2010; Longo et al. 2012). For instance, Bollars et al. compared the incidence, type, and severity of football injuries during the 1999-2000 and 2009-2010 seasons in Belgium. The national Royal Belgian Football Association has been implementing injury reduction programs as "The 11" and the "11+", as well as other preventive measures since 2008. Since the early 1990s, the Royal Belgian Football Association has rigorously collected data on all injuries in a national insurance registry. The study concluded that the introduction of injury prevention programs and preventive policies that aimed at the reducing some extrinsic risk factors, extreme weather conditions and fair play awareness, over a decade led to significant reduction in injuries amongst licensed football players. The researchers admit room for improvement, claiming that effectiveness of preventive programs can be enhanced if specific parameters are targeted, such as preconditioning programs before the season (Bollars et al. 2014).

A few systematic reviews have analysed the effectiveness of exercise interventions in the prevention of sports injuries in football (Lauersen et al. 2014; Van Beijsterveldt et al. 2013). Van Beijsterveldt et al. reviewed six studies with interventions focusing a preventive training programme, including a set of exercises aimed at improving strength, coordination, flexibility or agility, and reported that four of the six studies described an overall preventive effect however only two of the six studies reported a statistical significant reduction in their primary outcome – injuries overall. The small number of studies included in the review and the difference in key variables such as the participant's sex, level of play and age, as well as the components of the injury prevention program may justify the conflicting results observed amongst the studies (Van Beijsterveldt et al. 2013). Nevertheless, Lauersen et al. conducted a systematic review and meta-analysis of randomised controlled trials to determine the effectiveness of exercise interventions to prevent sports injuries and performed a stratified analyses of strength training, stretching and proprioception. They included 25 studies, and once again concluded, that the overall effect estimate on injury prevention was heterogeneous; nonetheless, they also showed that strength training, proprioceptive training and multiple exposures demonstrate a greater effect on injury reduction, however no beneficial effect was observed for stretching. Hence, these researchers support that a prerequisite for multiple exposure interventions should be, single exposures with proven effects on injury reduction. They recommend further research into single exposures, particularly strength training (Lauersen et al. 2014).

Although literature does not always show statistical significance in the outcomes assessed, injury prevention programs are of undeniable importance. Preventive measures should be a part of planning of a sports season, as any type of time-loss injury is associated to decreased sport participation of the athlete, which affects any level of team sports participation which leads to costs to the club, time-loss at work, as well as may lead to long-term morbidity and additional costs to the health system (Ekstrand et al. 2011; Richmond et al. 2013; Steffen et al. 2010; Polinder et al. 2016).

The FIFA 11+ and injuries: a simple answer to a complex problem?

The FIFA was founded in 1904 and admits, as one of its main goals, to continuously improve the game of football (FIFA 2016). An important mark of the Fédération Internationale de Football Association was the establishment of the FIFA Medical Assessment and Research Centre (F-MARC) in 1994. The systematic review by Junge and Dvorak, analysed 9 studies that considered the theme of injury prevention in football. The review revealed some evidence that multi-modal intervention programmes result in a reduction in injuries in general (Junge & Dvorak 2004). Consequently, F-MARC brought together a group of international experts to create an injury prevention program to address amateur players, so that the program would effectively reduce injuries on a large scale. The program had to be simple, attractive and time-efficient (F-MARC 2015). Officially published in 2005, “The 11” was created taking into account everyday training routines of amateur players, making it possible to reduce injuries on a large scale (F-MARC 2015). This program includes 10 exercises substantiated on scientific evidence or best-practice procedures reinforced by education and promotion of Fair Play, which is an essential feature in prevention of injuries. The FIFA 11 focuses core stabilisation, eccentric training of hamstrings, proprioceptive and balance training attending to the flexion of the knee and hip ("knees over toes") and with alignment of the leg, finalizing with 3 exercises of dynamic stabilisation and jump technique (plyometrics) attending again to the alignment of the leg (avoiding knee valgus) and requesting the forefoot landing with bent knees and hips. Requiring only a ball, the program can be executed at any time, even out of training sessions or match days, however advising for the daytime period (F-MARC 2015). This program has been tested in various studies with significant (Kilding et al. 2008; Junge et al. 2011), as well as without significant injury risk reduction and physical performance enhancement (Steffen et al. 2008; Van Beijsterveldt et al. 2012; Gatterer et al. 2012).

In 2006, the FIFA 11+ was created by the F-MARC with the collaboration of the Oslo Sports Trauma Research Centre and the Santa Monica Orthopaedic and Sports Medicine Research Foundation (Bizzini & Dvorak 2015; Dvorak et al. 2009). Notwithstanding, its promotion and consequent worldwide dissemination took place in 2009 (Bizzini & Dvorak 2015), as in 2008, the study by Soligard et al., showed the program's effectiveness in a large scale study with young female football players (Soligard et al. 2008). Likewise, this advanced version of "The 11", does not require specific equipment for execution (Bizzini et al. 2011). The "11+" was composed combining key exercises from its predecessor and the "Prevent Injury and Enhance Performance Program- PEP" (F-MARC 2015). The PEP Program was designed by an expert panel convened by the Santa Monica Orthopaedic and Sports Medicine Research Foundation in 1999, to prevent noncontact anterior cruciate ligament (ACL) injuries. This program addresses the strength and neuromuscular coordination of the stabilizing muscles around the knee. The 19 constituents of the program are intended to be used as a warm-up instead of being performed after the training or match, to avoid the deleterious effects of fatigue. The program takes less than 30 minutes to complete and comprises an initial warm-up, exercises for strengthening of the leg muscles, plyometrics with emphasis on soft landings, agility drills and ending with stretching of the lower limb muscles. There is a clear message in this program to optimize biomechanically technical skills during exercise execution. The fact that the program does not need specific equipment, leads to better acceptance and compliance within the targeted population (Gilchrist et al. 2008).

The FIFA 11+ aims at the prevention of the two most common injury types in football: ligament injuries of the ankle and the knee (F-MARC 2015). Major clinical research studies have clearly indicated that the consistent implementation of the “11+” can lead to a 30 – 50% reduction in injuries (Bizzini et al. 2011). As it has been already referred, the study by Soligard et al., was the first study that showed the program’s effectiveness with young female football players. The study enrolled 125 football clubs from Norway which were followed during the whole season (eight months). The sample that completed the study consisted of 93 teams accounting for a total of 1892 female players aged 13-17 (52 teams in the intervention group: 1055 players; 41 teams in the control group: 837 players). Throughout the season, 264 players sustained significant injuries, of which 121 players in the intervention group and 143 in the control group (RR 0.71, 95% CI 0.49 to 1.03). A significant lower risk of overall injuries was found in the intervention group (RR 0.68, 95% CI 0.48 to 0.98), overuse injuries (RR 0.47, 95% CI 0.26 to 0.85), and severe injuries (RR 0.55, 95% CI 0.36 to 0.83). Even though, no significant difference was found for the primary outcome of the study (reduction in lower extremity injury), the risk of severe, overuse, and overall injuries was reduced, demonstrating that the FIFA 11+ is capable in preventing injuries in young female football players (Soligard et al. 2008).

In 2014, Owoeye et al. enrolled 20 teams, including 414 youth male football players (aged 14-19 years) of the Lagos Junior League, in the Premier League division of Nigeria. The overall rate of injury in the FIFA 11+ group was reduced by 41% (RR 0.59, 95% CI 0.40 to 0.86, $p = 0.006$) and all lower extremity injuries by 48% (RR 0.52, 95% CI 0.34 to 0.82, $p = 0.004$). It was observed a lower relative risk of injury in the intervention group compared to the control group for overuse injuries (RR 0.26, 95% CI 0.07 to 0.98), acute injuries (RR 0.65, 95% CI 0.44 to 0.97) and mild injuries (RR 0.42, 95% CI 0.19 to 0.95). Furthermore, there was a strong tendency for a reduction in thigh ($p = 0.052$), ankle ($p = 0.08$) and non-contact injuries ($p = 0.056$) (Owoeye et al. 2014).

Table 1 resumes the main characteristics and results of studies which analysed the effects of the FIFA 11+ on injuries in football players; to our best knowledge no studies were conducted so far to evaluate the efficacy of the FIFA 11+ injury prevention program in the risk of injury in futsal players.
In summary, the majority of studies performed so far to analyse the risk of injuries with the FIFA 11+ show significant risk reductions, when the general requisites for the application of the program are fulfilled.

Does the FIFA 11+ induce performance and neuromuscular enhancements?
FIFA´s 11+ is composed by a specific sequence of 15 exercises divided in 3 parts which consist of exercises including running at progressive speeds, active stretching, plant-and-cut movements, controlled partner contacts, and a middle section with three levels of increasing arduousness contemplating agility, balance and plyometric exercises, as well as strengthening of the core and leg exercises. A main feature of the program is the requisite of adequate execution technique of the exercises, bringing the athletes attention to correct their posture and to promote commendable body control, comprising straight leg alignment, correct knee-over-toe position and soft landings. This program is recommended to replace the usual warm-up, preceding training (Bizzini et al. 2011).
The FIFA 11+ seems to induce positive acute and chronic effects on several physiological and performance parameters. Regarding the acute effects, a very elegant study by Bizzini et al., aimed the analysis of the immediate effects of the FIFA 11+ on several physical performance and physiological variables, to demonstrate the effectiveness of the program as an appropriate warm-up for football players. The variables tested included the 20m sprint, agility T-Test, countermovement and squat jumps, stiffness (using a hop test), isometric maximal voluntary contraction (MVC), rate of force development (RFD), and the star excursion balance test (SEBT). The results showed that beyond the potential of effective reduction of injury risk, the program also induces acute physiological responses that enhance the subsequent performance. This

Table 1. Summary of main data of studies which analysed the effects of the FIFA 11+ on injuries.

Reference	Participants	Design	FIFA 11+ Intervention			Follow-up	Main Results
			Frequency	Duration	Delivery		
Soligard et al., (2008).	Female, youth football players (13-17 years) IG: 1055 (15.4 ± 0.7 years) CG: 837 (15.4 ± 0.7 years)	RCT	2-5/week	8 M	Complete program as warm-up before training. Running exercises of the program as part of the warm-up before each match.	8 M	Lower risk of overall (RR = 0.68; 95% CI 0.48–0.98), overuse (RR = 0.47, 95% CI 0.26–0.85) and severe injuries (RR = 0.55, 95% CI 0.36–0.83) in the IG.
Soligard et al., (2010).	Female, youth football players (13-17 years) IG: 1055 (15.4 ± 0.7 years) CG: 837 (15.4 ± 0.7 years)	Prospective cohort study and retrospective survey based on a cluster-RCT	2-5/week	8 M	Complete program as warm-up before training. Running exercises of the program as part of the warm-up before each match.	8 M	Overall, the IG experienced a 30–50% reduction in the risk of various injuries compared with the controls. Players with high program compliance had a 35% lower risk of all injuries (RR = 0.65; 95% CI 0.46–0.91).
Grooms et al., 2013.	Male, collegiate football players (18-25 years) IG: 34 (20.0 ± 2.4 years) CG: 30 (20.3 ± 1.6 years)	Prospective single cohort	5-6/week	2 seasons (≈24 weeks)	Complete program before participating in each game or practice.	2 seasons (≈24 weeks)	Lower risk of lower extremity injury (RR = 0.28; 95% CI 0.09–0.85) and time lost due to lower extremity injury in the IG (54 vs. 291 days).
Steffen et al., 2013.	Female, youth football players (13-18 years) IG.RCF.:121 IG.C.:129 IG.UCG.:135	Cluster-RCT	2-3/week	4 M	Complete program as warm-up before participating in each game or practice.	4 M	Players with high adherence had a 57% lower injury risk (RR = 0.43; 95% CI 0.19–1.00). Yet, when adjustment for covariates was set, significance was not reached RR = 0.44; 95% CI 0.18–1.06.

Owoeye et al., (2014).	Male, youth football players (14-19 years) IG: 212 (17.80 ± 0.94 years) CG: 204 (17.49 ± 1.10 years)	Cluster-RCT	At least 2/week	6M	Complete program as warm-up during training sessions	6 M	41% reduction of the overall injury rate in the IG [RR = 0.59 (95% CI: 0.40 – 0.86)] and 48% reduction of all lower extremity injuries [RR = 0.52 (95% CI: 0.34 – 0.82)].
Hammes et al., (2014).	Male, veteran football players (≥32 years) IG: 146 (45 ± 8 years) CG: 119 (43 ± 6 years)	Cluster-RCT	1/week	9M	Complete program before training sessions.	9 M	Higher incidence of severe injuries in the CG [0.46 (0.21– 0.97), P = 0.04]. No differences in overall injury incidence between IG and CG [0.91 (0.64–1.48); P = 0.89].
Silvers-Granelli et al., (2015).	Male, collegiate football players (18-25 years) IG: 675 (20.40 ± 1.66 years) CG: 850 (20.68 ± 1.46 years)	Cluster- RCT	3/week	5M	Complete program before training and games.	5M	Significant reduction in injury rates by 46.1% and decreased time loss to injury by 28.6% in the IG.
Silvers-Granelli et al., (2017).	Male, collegiate football players (18-25 years) IG: 675 (20.40 ± 1.66 years) CG: 850 (20.68 ± 1.46 years)	Cluster- RCT	3/week	5M	Complete program before training and games.	5M	Less knee injuries in the IG (34) compared with the CG (102); relative risk [RR], 0.42; 95% [CI], 0.29-0.61; p<0.001). Fewer ACL injuries in the IG (3) compared with the CG (16); 4.25-fold reduction in the likelihood of ACL injury (RR, 0.24; 95% CI, 0.193–0.93; p<0.001).

CT, randomized controlled trial; m, months; IG, intervention group (FIFA 11+ group); CG, control group; RCF, regular coach-focused; CPF, comprehensive player-focused; UCG, unsupervised control group; AE, athletic exposure (participation in any team practice or game during preseason or in-season).

study showed that the level 3 of the FIFA 11+ can be considered comparable with other warm-up routines used in football, generating similar physiological enhancements (Bizzini, Impellizzeri, et al. 2013). Another recent study, by Ayala et al., tested the acute effects of the FIFA 11+, along with two other warm-ups, assessing several physical performance measures (joint range of motion of the hip, knee and ankle, isokinetic concentric and eccentric muscle strength for calculation of the hamstring to quadriceps (H/Q) conventional (Conv) and functional (Funct) strength ratios ($H/Q_{Conv}60$, $H/Q_{Conv}180$, $H/Q_{Funct}60$, $H/Q_{Funct}T180$, $H/Q_{Funct}30/240$), dynamic postural control with the Y-Balance test, 10 and 20m sprint, vertical drop jump height and reactive strength index. No substantial differences were shown for the majority of the physical performance measures. However, sprint time results showed substantial effects; the Harmoknee and FIFA 11+ warm-ups established slower sprint times when matched to the dynamic-warm-up for 20m (2.4%) and 10m (1.7%), respectively (Ayala, Calderón-López, et al. 2017). Considering that the performance results obtained by Ayala et al., are not in agreement with the results by Bizzini et al., we cannot disregard the FIFA 11+ to be an effective warm-up option to use before training sessions as it still shows a magnitude of the effects elicited by the injury prevention program on sprint times (2.2%), being comparable with those reported in the literature for dynamic warm-up routines (1.8%) (Bizzini, Impellizzeri, et al. 2013; Ayala, Calderón-López, et al. 2017).

Regarding the chronic effects, the study by Impellizzeri et al. followed for 9 weeks, 42 amateur football players submitted to the FIFA 11+ 3 times per week. The performance and neuromuscular control variables tested were eccentric/concentric extensors and flexors strength, sprint, agility, vertical jump, time-to-stabilisation test, core-stability test, and the SEBT. The study concluded that performing the FIFA 11+ 3 times per week during 9 weeks improves neuromuscular control and specifically the time-to-stabilisation which is an ability of particular interest for football players. The authors hypothesize that this mechanism may explain the injury prevention effect of FIFA 11+. Although some significant improvements were found for flexors strength, the authors do not consider the practical importance of these changes as certain (Impellizzeri et al.

2013). However, most of the FIFA 11+ studies which test strength parameters, using isokinetic testing (Brito et al. 2010; Daneshjoo et al. 2012b; Impellizzeri et al. 2013; A Daneshjoo et al. 2013; Reis et al. 2013; Ghareeb et al. 2017; Ayala, Calderón-López, et al. 2017), revealed significant gains in at least some of the strength parameters tested.

Other performance parameters have been analysed in other studies including the FIFA 11+ intervention. For instance, speed (Abdolhamid Daneshjoo et al. 2013; Bizzini, Impellizzeri, et al. 2013; Impellizzeri et al. 2013; Reis et al. 2013; Ayala, Pomares-Noguera, et al. 2017), jump performance (Abdolhamid Daneshjoo et al. 2013; Bizzini, Impellizzeri, et al. 2013; Impellizzeri et al. 2013; Reis et al. 2013; Silva et al. 2015; Steffen et al. 2013; Ayala, Pomares-Noguera, et al. 2017), agility (Abdolhamid Daneshjoo et al. 2013; Bizzini, Impellizzeri, et al. 2013; Impellizzeri et al. 2013; Reis et al. 2013; Ayala, Pomares-Noguera, et al. 2017), flexibility (Ayala, Pomares-Noguera, et al. 2017), static balance (Daneshjoo et al. 2012a; Steffen et al. 2013; Reis et al. 2013; Dunsky et al. 2017), dynamic balance (Daneshjoo et al. 2012a; Steffen et al. 2013; Bizzini et al. 2013; Impellizzeri et al. 2013; Dunsky et al. 2017; Ayala, Pomares-Noguera, et al. 2017; Ayala, Calderón-López, et al. 2017) and proprioception (Daneshjoo et al. 2012a; Abdolhamid Daneshjoo et al. 2013).

Table 2 shows a summary of the effects of FIFA 11+ on performance and neuromuscular parameters. Regardless the significant amount of studies encompassing FIFA’s 11+, some discrepancies between the results exist. For instance, several studies showed an improvement of speed (Reis et al. 2013; Ayala, Pomares-Noguera, et al. 2017), but others failed to show an improvement after the program (Impellizzeri et al. 2013; Abdolhamid Daneshjoo et al. 2013). The results of the studies that assessed jumping performance are also not

Table 2. Summary of main effects on performance and neuromuscular parameters of the FIFA 11+.

Reference	**Participants**	Design	FIFA 11+ Intervention			**Velocity**	**Jump Performance**	**Agility**	**Flexibility**	**Static Balance**	**Dynamic Balance**	**Proprioception**	**Strength**
			Frequency	Duration	Deliver								
Brito et al., (2010).	Sub-elite male football players (n=18)	Cohort study	3/week	10 weeks	Not reported	N/A	N/A	N/A	N/A	N/A	N/A	N/A	+
Daneshjoo et al., (2012).	Under-21-year-old male professional football players (n=36)	RCT	3/week	2 M	Warm-up	N/A	N/A	N/A	N/A	+	+	+	N/A
Daneshjoo et al., (2013)a.	Under-21-year-old male professional football players (n=36)	RCT	3/week	2 M	Warm-up	-	+	+	N/A	N/A	N/A	N/A	N/A
Daneshjoo et al., (2013)b.	Under-21-year-old male professional football players (n=36)	RCT	3/week	2 M	Warm-up	N/A	N/A	N/A	N/A	N/A	N/A	N/A	+[1]
Daneshjoo et al., (2013).	Under-21-year-old male professional football players (n=36)	RCT	3/week	2 M	Warm-up	N/A	N/A	N/A	N/A	N/A	N/A	N/A	+[2]
Impellizzeri et al., (2013).	Male amateur football players (n=81)	RCT	3/week	9 weeks	Warm-up	-	-	-	N/A	+	-	N/A	+
Reis et al., (2013).	Adolescent male futsal players (n=36)	RCT	2/week	12 weeks	Warm-up	+	+	+	N/A	+	N/A	N/A	+
Steffen et al., (2013).	Female, youth football players (n=226)	Cohort of a larger Cluster RCT	2-3/week	4 M	Warm-up	N/A	-	N/A	N/A	+	+	N/A	N/A
Silva et al., (2015).	Under-20 Male elite football players (n=20)	Cohort study	3/week	9 weeks	Warm-up	N/A	+	N/A	N/A	N/A	N/A	N/A	N/A
Ghareeb et al., (2017).	Male high school football players (n=34)	Cohort study	3/week	6 weeks	Warm-up	N/A	N/A	N/A	N/A	-	N/A	N/A	+
Dunsky et al., (2017).	Male young amateur football players (n=20)	Cohort study	3/week	6 weeks	Warm-up	N/A	N/A	N/A	N/A	+	+	N/A	N/A

Ayala et al., (2017).	Male, adolescent amateur, football players (n=41)	RCT	3/week	4 weeks	Warm-up	+	+	-	-	N/A	+	N/A	N/A

+ Significant improvement; - Without significant improvement; 1 isometric strength; 2 isokinetic strength.

consensual, some showing significant improvements (Abdolhamid Daneshjoo et al. 2013; Reis et al. 2013; Ayala, Pomares-Noguera, et al. 2017; Silva et al. 2015) as well as some demonstrating the absence of positive results (Impellizzeri et al. 2013; Steffen et al. 2013). Concerning agility, a few studies showed agility enhancement (Abdolhamid Daneshjoo et al. 2013; Reis et al. 2013), yet no improvements were observed in other studies (Impellizzeri et al. 2013; Ayala, Pomares-Noguera, et al. 2017).

FIFA 11+ related studies have also focused balance parameters, following the same path of lack of consensual results. As the majority show significant gains in static (Daneshjoo et al. 2012a; Steffen et al. 2013; Reis et al. 2013; Dunsky et al. 2017) and dynamic balance (Daneshjoo et al. 2012a; Steffen et al. 2013; Bizzini, Impellizzeri, et al. 2013; Dunsky et al. 2017; Ayala, Pomares-Noguera, et al. 2017), still a few did not observe improvements, in static (Ghareeb et al. 2017) and in dynamic balance (Impellizzeri et al. 2013).

In a lesser way, flexibility and proprioception have also been studied regarding FIFA 11+ intervention. Only two studies, from the same group were found with FIFA 11+ intervention addressing flexibility, the first assessing the acute effects of the injury prevention program (Ayala, Calderón-López, et al. 2017) and the last the effects of a 4 week intervention (Ayala, Pomares-Noguera, et al. 2017), however both studies revealed absence of significant improvements. Regarding proprioception, only one study retrieved focused the effects of FIFA 11+ on joint position sense (JPS) of football players (Daneshjoo et al. 2012a) demonstrating significant improvements in the dominant leg at 45º and 60º of knee flexion, after 2 months of intervention (24 FIFA 11+ sessions). In that study, the authors concluded that the improvement showed in proprioception and balance may enhance performance and prevent injuries specifically in the lower limbs.

The diversity of studies that have assessed the effects of the FIFA 11+ provide results supporting the notion that FIFA 11+ is an effective warm-up program, able to replace the traditional warm-up, however it is uncertain that it may be used as a strategy to improve performance, or other physical and functional variables, such as muscle strength (namely hamstrings eccentric strength), postural stability, agility, balance and neuromuscular control. The understanding of the impact of FIFA 11+ performed for several weeks on the referred variables could help to explain how it is capable to reduce the incidence of injuries during the season.

Purposes and structure of the thesis

The FIFA 11+ injury prevention program was developed by the Fédération Internationale de Football Association for amateur football, reaching the bulk of football players around the world. The majority of studies found in literature regarding sports have shown the positive results obtained in the reduction of injury risk, in the enhancement of performance as well as the enhancement of some neuromuscular parameters, notwithstanding, with some controversy.

As referred before, the only futsal study retrieved (Reis et al. 2013) was performed in male youth futsal players. We considered that it was of interest to analyse the physical performance and neuromuscular variables of senior futsal players that play at an amateur level and consequently have lesser weekly training hours, worse training conditions, fewer training staff, which do not have access to state-of-the-art gyms and recovery enhancement facilities, and overall, do not have permanent support of a medical team or a physiotherapist. Despite the fact that the majority of futsal players in national territory are amateurs, the majority of the above mentioned studies enrolled professional football players or young players at school age. Hence, this study aimed to analyse the impact of an injury prevention program (FIFA 11+) on physical performance and neuromuscular variables in amateur male futsal players as well as injury prevention during the study period.

To our knowledge, the only study regarding futsal revealed promising results in this fast growing modality, creating great expectations that the program may suit the injury prevention requirements of futsal players.

Taking this into account, the following general and specific objectives were defined:

To determine the short and long-term effects of the FIFA 11+ injury prevention program on performance, neuromuscular function and injury prevention in amateur futsal players.

1. To examine the short and long-term effects of the FIFA 11+ injury prevention program on four physical performance tests, speed, agility, jump performance and flexibility of amateur futsal players.
2. To determine the short and long-term effects of the FIFA 11+ injury prevention program on static and dynamic balance and proprioception of amateur futsal players.
3. To investigate the effects of the FIFA 11+ program on evertor muscles latency time in simulated sudden inversion, isokinetic strength and H/Q ratios in amateur futsal players.
4. To study the effects of the FIFA 11+ program on injury prevention in amateur futsal players.

The current thesis is arranged in agreement with the Scandinavian doctoral thesis model and is divided in five chapters.

The first chapter covers the introduction to the sport modality of futsal and the FIFA 11+ injury prevention program, where the rational to perform this work is presented. This initial chapter finishes with the presentation of the general and specific objectives of the research project. The second chapter, entitled “Original research manuscripts”, comprises the experimental component of this work being compounded by four original studies aiming to answer the proposed specific objectives. The third chapter is the “Discussion” chapter, constituted by a Discussion of Methodology, where the study parameters that were selected are discussed, followed by a Discussion of Main Results, where it is discussed the main results of the original studies produced. The fourth chapter encompasses the main conclusions of the thesis and perspectives for future research. The fifth and final chapter, presents the bibliographic references that give provision to the first and third chapters.

CHAPTER 2

ORIGINAL RESEARCH MANUSCRIPTS

STUDY I

The FIFA 11+ does not alter physical performance of amateur futsal players.

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Submitted. Waiting for final decision.

Journal of Sports Medicine and Physical Fitness

The FIFA 11+ does not alter physical performance of amateur futsal players.

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Acknowledgments

The European Regional Development Fund through the Operational Competitiveness Program, and the Portuguese Foundation for Science and Technology (FCT) support the research unit CIAFEL (REF: UID/DTP/00617/2013). iBiMED is a research unit supported by the Portuguese Foundation for Science and Technology (REF: UID/BIM/04501/2013) and and POCI-01-0145-FEDER-007628 funds.

ABSTRACT

BACKGROUND: The ability of the FIFA 11+ to enhance performance has demonstrated controversial results. Hence, we examined the short and long-term effects of the FIFA 11+ on performance in male amateur futsal players.

METHODS: Seventy-one male futsal players from six amateur clubs were recruited and randomized to an intervention (n=37, age: 27.0±5.1 years) or a control group (n=34, age: 26.0±5.1 years). The intervention group was submitted to 10 weeks of FIFA 11+ injury prevention program, 2 sessions/week, followed by a 10-week follow-up period, while the control group performed regular futsal warm-ups during the training sessions. During the follow-up period both groups performed only regular warm-ups during their training sessions. Physical performance was assessed by measuring agility (T-test), sprint (30m sprint), flexibility (sit-and-reach test) and vertical jump performance (squat jump).

RESULTS: Differences between groups were found at baseline for training exposure, body mass index, body weight, flexibility and sprint. The results of the effect of the FIFA 11+ on the sit-and-reach test, speed and agility did not show differences pre-post intervention, as well as for the 10-week follow-up. Jump performance, showed a significant difference in favour of the control group for the intervention period and the follow-up [Crude β, -0.04 (-0.06; -0.01); -0.03 (-0.06; -0.00), respectively], however after adjustment for the baseline differences the confidence interval fell out of the range of significance for the intervention and follow-up period [Adjusted β, -0.05 (-0.10; 0.00); -0.05 (-0.10; 0.04)].

CONCLUSIONS: The present study has shown no short and long-term performance enhancement in sprint, flexibility, agility and jump performance after the FIFA 11+ in male amateur futsal players.

KEY WORDS: FIFA 11+, warm-up, futsal, performance, amateur players.

Introduction

Futsal is considered to be the World's fastest growing indoor sport [1] being estimated to have over 30 million players worldwide.[2] As participation numbers grow so must the awareness to injury prevention. It is known that injuries in football may affect any age or sex group, and any skill level.[3] Although there are some differences between the most popular football game (soccer) compared to futsal, there are similarities in the risks that the players are exposed, therefore the injuries that may occur in both modalities, naturally may share similarities.[4] Despite the fact that location and diagnosis of injuries endure analogies in the two forms of football, futsal tends to fewer contact and foul play injuries compared to football.[4] Nonetheless, any type of time loss injury is associated to decreased sport participation, which affects any team, at whatever level of sports participation, leading to costs to the club, time loss at work, as well as may lead to long-term morbidity and additional costs to the health system.[5–8]

It is clear that preventive measures should be part of planning of a sports season, since literature has shown the benefits of injury prevention programs.[9–24] It is widely known that FIFA´s 11+ is composed by a specific sequence of 15 exercises divided in 3 parts which consist of progressive sprints, active stretching, plant-and-cut movements, controlled partner contacts, and a middle section with three levels of increasing arduousness contemplating agility, balance and plyometric exercises, as well as strengthening of the core and leg exercises. Based on the sequence of exercises used by the "11+", many studies have approached the analyses of the effects of the program on performance components, such as sprint,[25–29] jump performance,[25–31] agility [25–29] and flexibility.[29] Regardless the significant amount of studies in turn of FIFA's 11+, some discrepancies between the results exist. Several studies showed an improvement of sprint,[28,29] jumping performance [25,28–30] and agility;[25,28] however others failed to demonstrate positive results in the same parameters, such as sprint,[25,27] jumping performance,[27,31] agility [27,29] and flexibility.[29,32]

Additionally, to our knowledge, only one study [28] was performed in male youth futsal players. It may be interesting to also analyse physical performance variables of senior futsal players that play at an amateur level and consequently have lesser weekly training hours, worse training conditions, fewer training staff, do not have access to state-of-the-art gyms and recovery enhancement facilities, and overall, do not have permanent support of a medical team or a physiotherapist. Despite the fact that the majority of futsal players in our country are amateurs, the majority of the above-mentioned studies enrolled professional football players or young players at school age. Hence, this study aimed to analyse short and long-term effects of an injury prevention program (FIFA 11+) on physical performance variables in amateur male futsal players.

Material and Methods

Study design and randomisation procedures

A parallel, two-group, stratified randomised controlled trial was performed. The teams that were fully eligible to participate in the study were randomized and allocated (allocation ratio 1:1) by a blinded assistant, without any affiliation or recognition of the teams, to the control and FIFA 11+ groups. Randomization was executed by the means of selection of one of two sealed, opaque, envelopes containing group allocation. All teams, in both groups, were tested at 3 stages: at baseline (T0), after the 10th full week of intervention (T1), and after a 10-week follow-up period comprising only the normal warm-up routine during their training sessions (T2). All assessments were conducted 48 hours after the last training session or match.

At each evaluation stage, the participants were submitted to the following assessments: 30m sprint; agility (T-Test); vertical jump (squat jump) and flexibility (sit-and-reach test). The order of the assessments was randomly determined.

Data collection forms, procedures and definitions used in this study, were in accordance with international consensus guidelines for injury surveillance in football. [33]

Participants

Interest solicitations were made by e-mail to all amateur senior male futsal teams competing in the Football Associations of Coimbra and Aveiro, Portugal. Of 34 teams invited, 24 agreed to participate. The details of the study were explained by the researcher to the managers and players of the teams. To obtain full consent of the team (including players, managers and directors), a period of 4 weeks was given. After this period, 14 teams accepted to participate in the study; the reasons given to decline participation were no interest in changing their practice routines or lack of time to perform the assessments due to work commitment of players. Randomly 6 teams were selected and allocated by an assistant blinded to the studies' purpose, into two groups: control (3 teams) and FIFA 11+ (3 teams) (Figure 1).

The players in each team were thereafter submitted to eligibility criteria. The inclusion criteria for this study were: 1) male amateur futsal players competing in the Official Regional Amateur Futsal Championships of the District of Aveiro (1st and 2nd division) and Coimbra (unique division) of the Portuguese Football Federation; 2) players aged ≥ 18 years; 3) players that did not have contact with the FIFA 11+ in past years; 4) attendance to at least 2 training sessions per week plus match (which excluded players that had less training sessions because of job compromises which can be frequent in amateur teams). Exclusion criteria: players which stopped training due to a serious time loss injury (3 weeks or more) in the 3 months before the study initiation; players that suffered health problems during the study period, affecting the research parameters and those whose suspension or reintegration to the sport activity coincided with the evaluation period. Additionally, players who changed club during the study or those in the intervention group who failed to attend to at least 80% of the FIFA 11+ sessions were excluded from the analysis.

The study received approval from the ethics committee of the Faculty of Sport of University of Porto. Participants provided written informed consent and all procedures were conducted according to the Declaration of Helsinki.

Settings and locations where the data were collected

The research was conducted during the futsal championship of 2014/15 in Portugal (Aveiro and Coimbra). The testing, which took place in the teams own sports hall, commenced in September 2014 with baseline measurements and ended in February, 2015. The time frame of the study was selected so that it would allow the 3 testing moments, and would be complete before approximation of the ending of the championship.

Interventions

The administration of FIFA 11+ was guaranteed by the coach and one or two players (normally the captain and sub-captain of the team), with former formation guaranteed by a researcher. We chose the coach as the key element to administer the program to assure a better rate of compliance of the players towards the program.[34,35] Paper and video support was disposed to the participants in the 3 teams in the FIFA 11+ group. All teams started in level 1, and progressed to the next level in three weeks as foreseen in the FIFA 11+ manual,[35] which meant that all teams had 4 weeks of FIFA 11+ in level 3. The FIFA 11+ was executed twice a week, which is the minimum recommendation to achieve the proclaimed effects of the program. The average duration of the FIFA 11+ warm-up was 20 minutes which matched the average time of the normal warm-up of the control group. The warm-up of the control group was similar in the 3 teams, in which all integrated a combination of running, ball and dynamic stretching exercises managed in progressive order of speed and intensity. The teams were visited on a regular basis by a researcher and an assistant to make sure the program was executed correctly. The frequency of sessions was recorded on a diary.

Outcome measures

All assessment protocols were previously demonstrated and individually explained to each player before execution. All players tested wore sports clothes (t-shirt and shorts and futsal specific shoes). Considering the squat jump and flexibility testing, the players were tested without shoes, but kept their socks on. Regarding the winter periods of testing, where temperatures reached 14ºC in the sports hall, players had adequate sports equipment to keep warm. Before testing, all players executed a 10 minute standardized warm-up, including progressive sprint running (forward backwards and sidestepping), general mobilization (arms and legs) dynamic stretching and jump exercises. Tests were administered and recorded in the 3 stages of testing during the study by the same adequately trained personnel. All tests were performed three times and the best trial was used for statistical analyses.

Player's baseline characteristics: Player´s position, age, height, weight, dominant leg and details of previous major injuries were recorded with the pre-designed questionnaire.[33] The body weight was obtained with a medical Body Composition Analyzer (seca mBCA 525, Seca, Birmingham, UK) and the height of the players with a digital stadiometer (seca 264, Seca, Birmingham, UK). Calculation of body mass was calculated from the ratio of weight (kg) to squared height (m^2).

The agility T-test. All players had 3 experimental drills before the execution of 3 trials, with 3 minute resting before each attempt. The T-test arrangement was set on the teams' own sports hall. The players stood immediately behind the start/finish line and ran to the first cone placed away 10m where they had to touch its base with the right hand, before shuffling to the left and touching the base of the cone placed away 5m with the left hand. Then shuffled right to the other cone on the right, 10m away, where they had to touch the base with the right hand. Afterwards they had to shuffle left to touch the middle cone with the left hand and finally ran backwards to the finish line. Time was registered by a Brower Timing TC-System (Brower Timing Systems, Utah, USA). Two units of the wireless timing device were mounted facing each other on tripods at 0.75m above ground, with a distance of approximately 3m between. The timing started and stopped as the player cut across the sensor plane. The test was validated if the player touched all the bases of the cones and if shuffling of the feet did not occur.[36]

The squat jump. The testing was executed with an electrical contact operated system (Globus Ballistic Assessment, Globuscorporation, Italy) which measures the flight time and calculates elevation. The players had 2 submaximal and 1 maximal attempts before the 3 testing trials. Each player had 2 minutes of recovery in-between tests. The players started in a semi-squatted position (90º of flexion of the knees) having to rapidly extend the legs and the hips with both hands resting on the hips during the entire jump with prerequisite to land in the same point of take-off. The test had to be executed without countermovement to be considered valid.[37]

The sit-and-reach test. A standard sit-and-reach box (30.5cm high) with a sliding marker on the top of the box with an overlying metric scale, was used for testing. The test was preceded by 3 experimental try-outs before the 3 testing trials. The players had to sit on the floor with knees straight and with feet in full contact with the sit-and-reach box. The test was executed with hands facing down, side by side, not allowing that one hand advanced more than another. The players were asked to reach with their hands as far as possible, slowly during expiration, having to maintain the position at least 2 seconds to validate the score.[38] The trial was supervised by a trained tester to guarantee the maintenance of the knee extension and correct foot and heel contact. No jerky movements were allowed. The sit-and-reach is marked so that the scores are always positive (starting 26 cm before the edge of the box). Scores were recorded to the millimetre.

The 30m sprint. The players made 3 practice trials before 3 maximal sprints for testing. Each player had at least 4 minutes of recovery time before each trial.[39] The players stood behind the start line (0m behind the starting photocell gate). The sprint tests were performed on the team's own sports hall on a track traced on the playing field. The sprint time was recorded using a Brower Timing TC-System (Brower Timing Systems, Utah, USA).

Sample size calculation and data analysis

Power calculation was computed a priori based on the effect size (0.538) in agility (T test) obtained from a previous study enrolling futsal players.[28] Based on a power of 0.80 and a one-sided 5% significance level, a total sample size of 26 participants per group was required to detect changes between groups in agility. A target of 30 participants per group was identified to accommodate a dropout rate of 15%, hence we aimed to recruit 3 teams per group.

Analyses were performed on SPSS version 19.0 (SPSS Inc, Chicago, IL, USA). The normality of data distribution was tested with the Shapiro-Wilk test. Descriptive statistics comprised mean and standard deviation (SD). The independent T-test was used to compare participants' characteristics between groups at baseline. The difference between post-intervention and baseline (short-term effect) and between follow-up and baseline (long-term effect) was computed for each outcome. Crude and Adjusted Beta (β) and respective 95% confidence intervals (95% CI) were used to estimate the immediate and long-term effects of FIFA 11+ program. Statistical significance was set at $p < 0.05$ for all tests.

Results

From the 91 futsal players who agreed to take part in the study, 20 did not fulfil the inclusion criteria. The athletes that did not meet the inclusion criteria were athletes that regularly assisted to only one weekly training session, due to work related or study related schedules/commitments. Consequently, a total of 71 players participated in the study, in the FIFA 11+ (n=37) or the control group (n=34); the flow diagram of the participants is presented in Figure 1. The average FIFA 11+ exposure per week was 1.9 ± 0.09 sessions.

Baseline characteristics and outcome measures values of the FIFA 11+ group and control group were similar, except for the body mass index, body weight, number of training sessions per week (training exposure), squat jump and 30m sprint (Table 1). The players in the FIFA 11+ group showed a lower weight ($p = 0.019$), body mass index ($p = 0.027$) and better performance on the squat jump ($p = 0.022$) and 30m sprint ($p = 0.035$). Due to the fact that some teams randomly selected for the experimental group added additional weekly training sessions for tactical and technical reasons, the number of training sessions per week was significantly higher on the FIFA 11+ group ($p < 0.001$).

The effects of the intervention and follow-up on the outcomes measures are shown on Table 2 and Figure 2 and 3. The results of the effect of the FIFA 11+ on the sit-and-reach did not show differences pre-post intervention (short-term effect), as well as after the 10-week follow-up (long-term effect) before [Crude β, -0.05 (-1.62; 1.51); 0.10 (-2.76; 2.96), respectively] and after adjustments [Adjusted β, -0.02 (-2.96; 2.96); -1.51 (-7.07; 4.05)], which means that the value remained without significance after adjustment for group characteristics and training exposure (Figure 3). In the vertical jump performance, there is a significant difference in favour of the control group for the short and long-term effects [Crude β, -0.04 (-0.06; -0.01); -0.03 (-0.06; -0.00), respectively], however after adjustment the confidence interval fell out of the range of significance for the short and long-term effects [Adjusted β, -0.05 (-0.10; 0.00); -0.05 (-0.10; 0.04)]. Likewise, agility and sprint did not show improvements, after the intervention neither after the follow-up period, unvarying considering the baseline differences between the groups (Table 2, Figure 2, 3).

Discussion

This study aimed to assess the effects of the FIFA 11+ program on performance outcomes amongst amateur futsal players. The results indicated that the players included in the study and performed the FIFA 11+ during 10 weeks did not improve in sprint, vertical jump performance, agility and flexibility parameters.

The results obtained for sprint are in agreement with those of previous studies assessing the effects of FIFA 11+; Daneshjoo et al.[25] implemented the FIFA 11+ during 8 weeks in 36 male professional soccer players (17-20 years) and found no significant differences in the sprint tests; Impellizzeri et al.[27] found similar results in the 20m sprint, after 9 weeks of FIFA 11+, in 81 male amateur football players (FIFA 11+, n=42; control, n=39). Conversely, two studies observed a significant improvement in sprint performance with the FIFA 11+; a recent study,[29] which enrolled 41 adolescent (16.8 ± 0.7 years) amateur football players (n=10 in the FIFA 11+ group), showed a significant improvement in the 10m (8.4%) and 20m (1.8%) sprint after 4 weeks, with 3 FIFA 11+ sessions per week. Reis et al. [28] also showed significant enhancements after the FIFA 11+ in a group of youth futsal players (17.3 ± 0.7 years), in the 5m and 30m sprint with an improvement of 8.9% and 3.3%, respectively. To our best knowledge, the study by Reis et al. is the only study performed in futsal players. Although our study shares the same sports activity, and similar exposure to the FIFA 11+ (1.8 sessions/week), the participants age average is almost 10 years higher in our study. The player's age could partially explain the contrasting results. As suggested by Soligard et al. [17] one of the aims in sports injury prevention is to improve movement patterns, making them less vulnerable, therefore it is possible that injury prevention programs have more noteworthy physical impacts in more youthful players, since they have not yet established their elementary movement patterns.

The above mentioned studies,[25,28,29] also showed improvement in jump performance after the FIFA 11+ program. Silva et al. [30] found the same results in jump performance (squat jump and countermovement jump) after 9 weeks of FIFA's 11+ in 10 professional, high level, under-20 football players. But, as for the sprint, other studies did not find differences in countermovement jump performance after the FIFA 11+.[27,31] In a large study that enrolled female youth football players (13-18 years) from the top three levels of play, Steffen et al.[31] also failed to show a positive impact of the FIFA 11+ on vertical jump performance (jump-over-a-bar test). The authors suggested that the intensity of the plyometric exercises could be too low to enhance jumping parameters, as the main objective may be to raise the player's awareness to proper jumping technique and body alignment. [31]

As the FIFA 11+ focuses on appropriate biomechanical technique and enhanced consciousness and movement control during diverse activities as standing, running, planting, cutting, jumping, and landing,[17] the lack of improvement in agility was not expected. Nonetheless, several studies [27,29] also did not observe positive results in agility after the FIFA 11+. When comparing football and futsal male players, the results of the agility tests may be similar,[40] however, when comparing agility and reaction time between female football players and futsal players, futsal players are significantly faster in reactive agility and in decision-making.[41] In another study comparing female football and futsal players, the training sessions of futsal observed were more intense, as the physiological demands of the sport, in comparison to football training sessions.[42] This may lead to suspect, as in the vertical jumping performance, that the warm-up routine of the FIFA 11+, may be useful for preparation for sports activity but may not be sufficient to enhance agility of adult amateur futsal players.

Regarding flexibility, our results are similar to those reported by Ayala et al.;[29] they did not find improvements in flexibility testing (passive straight leg raise test; modified Thomas test; weight-bearing lunge with knee extended test). Even though no study was found using sit-and-reach performances with FIFA 11+ interventions, this method of testing shows high reliability,[43] and has the advantage of being a simple field test that allows the assessment of a large number of athletes in a short period of time. Flexibility is considered an essential element in physical performance.[43] The lack of improvements in flexibility are not completely unexpected, as the FIFA 11+ does not focus specifically flexibility.

There are a few limitations that should be addressed. First, all testing were executed in post-work schedule, as all players were amateurs and had a day job. All the testing sessions were executed in the beginning of the week, maintaining the same schedule as training days, accounting always for the 48h period rest post-match. Nonetheless, we did not control for the work hardness, so the physical or mental effort of the day of work may have had an influence on the parameters evaluated. Second, this study was performed during the season, so some players played more games or minutes per game than others, which could have affected physical performance. Third, by enrolling players from different teams, we cannot guarantee that the methods of training of the coaches were the same. Fourth, all the assessments were made in the teams' gym which made impossible to control for the air temperature inside the gym as none of the facilities had air conditioning or other form of heating/cooling system.

Conclusions

The present study has shown that no performance enhancement in sprint, flexibility, agility and jump measures was obtained with 10 weeks of FIFA 11+, in male amateur futsal players. The lack of meaningful effects in the performance measures suggests that the FIFA 11+ program should not be seen as a training strategy for improving the above mentioned parameters.

Acknowledgements

We gratefully acknowledge Mr Norberto Rei for his helpful involvement during the experiment. We would also like to acknowledge the commitment and dedication of all players, coaches and sports staff, and all technical supporting personnel, which made this study possible.

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Table 1. Baseline characteristics of the players stratified by group (mean ± SD).

	FIFA 11+ Group	*Control Group*	*P value*
Age (years)	27.3 ± 4.33	25.7 ± 4.61	0.171
Weight (kg)	73.2 ± 9.82	79.2 ± 9.28	**0.019**
Height (cm)	174.6 ± 7.22	177.1 ± 6.28	0.289
Body Mass Index (kg/m^2)	23.8 ± 2.36	25.3 ± 2.56	**0.027**
Training exposure from T0-T1 (sessions/week)	2.7 ± 0.18	1.8 ± 0.43	**<0.001**
Training exposure from T0-T2 (sessions/week)	2.6 ± 0.30	1.8 ± 0.36	**<0.001**
Flexibility (cm)	36.2 ± 8.03	33.3 ± 7.98	0.154
Squat jump (m)	0.40 ± 0.067	0.37 ± 0.057	**0.022**
Agility (sec)	11.3 ± 0.60	11.5 ± 0.77	0.430
30m sprint (sec)	4.3 ± 0.19	4.4 ± 0.24	**0.035**

Table 2. Effects of FIFA 11+ and follow-up (Linear Regression).

	Effect of the intervention		Follow-up	
	Crude β (95% CI)	*Adjusted* β (95% CI)*	*Crude β (95% CI)*	*Adjusted* β (95% CI)*
	Flexibility (sit-and-reach test)			
Group				
FIFA 11+	-0.05 (-1.62; 1.51)	-0.02 (-2.96; 2.96)	0.10 (-2.76; 2.96)	-1.51 (-7.07; 4.05)
Control	0	0	0	0
Age	-	-0.09 (-2.74; 0.10)	-	-0.05 (-0.39; 0.30)
Body Mass Index	-	0.02 (-0.33; 0.36)	-	-0.19 (-0.85; 0.46)
Training Exposure	-	0.15 (-2.38; 2.67)	-	1.54 (-3.54; 6.61)
	Vertical Jump (Squat jump)			
Group				
FIFA 11+	**-0.04 (-0.06; -0.01)**	-0.05 (-0.10; 0.00)	**-0.03 (-0.06; -0.00)**	-0.05 (-0.10; 0.04)
Control	0	0	0	0
Age	-	0.00 (-0.00; 0.01)	-	0.00 (-0.00; 0.01)
Body Mass Index	-	-0.00 (-0.01; 0.00)	-	0.00 (-0.01; 0.01)
Training Exposure	-	0.01 (-0.04; 0.06)	-	0.24 (-0.03; 0.08)
	Agility (T Test)			
Group				
FIFA 11+	0.05 (-0.25; 0.34)	0.06 (-0.50; 0.62)	-0.05 (-0.42; 0.31)	-0.12 (-0.79; 0.56)
Control	0	0	0	0
Age	-	-0.01 (-0.05; 0.02)	-	-0.04 (-0.08; 0.00)
Body Mass Index	-	0.03 (-0.04; 0.09)	-	0.04 (-0.04; 0.12)
Training Exposure	-	0.05 (-0.43; 0.53)	-	0.21 (-0.41; 0.82)
	Sprint (30m sprint)			
Group				
FIFA 11+	0.03 (-0.07; 0.13)	0.08 (-0.11; 0.27)	0.09 (-0.01; 0.19)	0.08 (-0.10; 0.27)
Control	0	0	0	0
Age	-	-0.01 (-0.02; 0.01)	-	-0.01 (-0.02; 0.01)
Body Mass Index	-	0.01 (-0.01; 0.03)	-	-0.01 (-0.03; 0.01)
Training Exposure	-	-0.03 (-0.19; 0.13)	-	-0.00 (-0.17; 0.17)

* Adjusted to all the variables presented in the table 1.

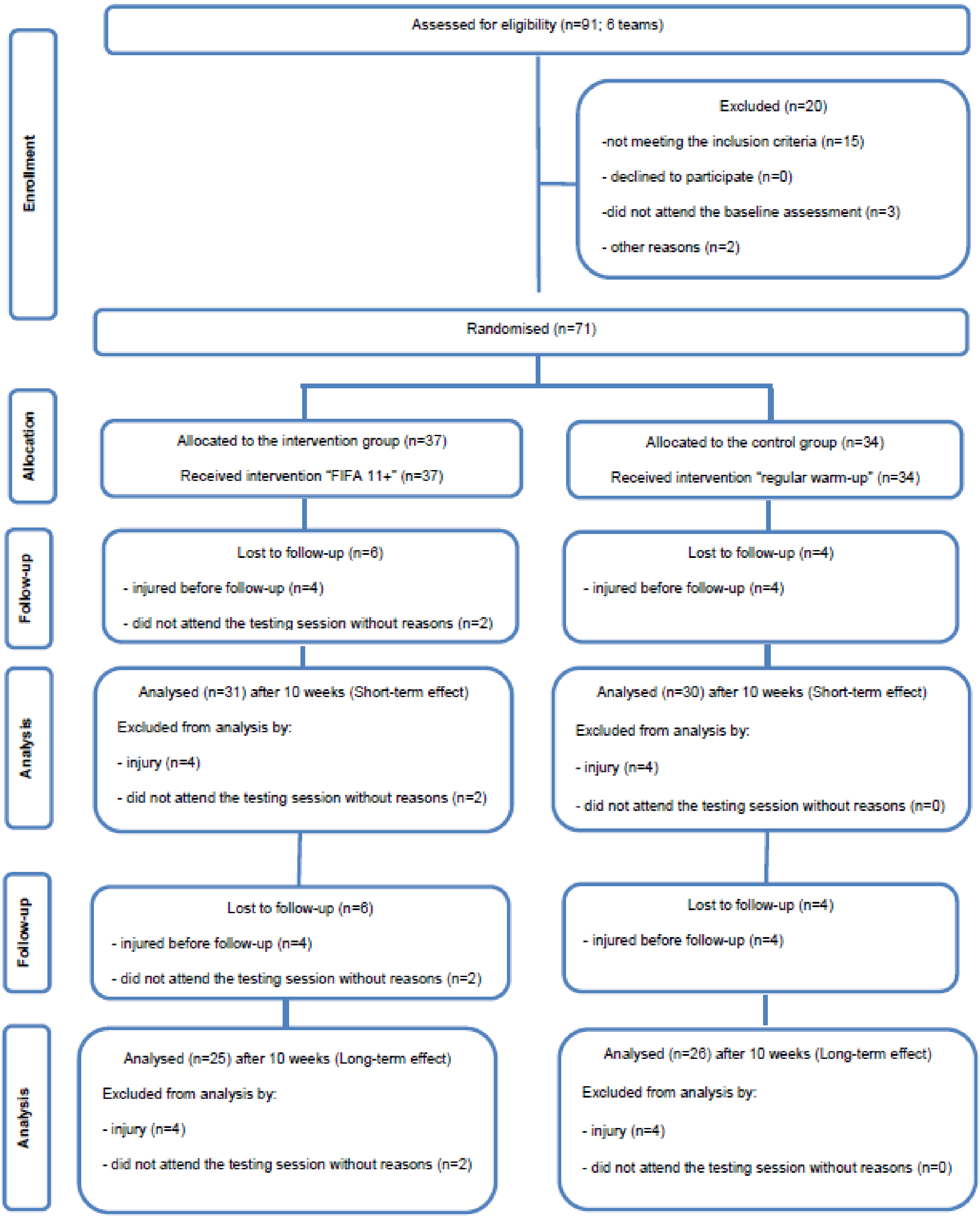

Figure 1. Flow-chart depicting the study design.

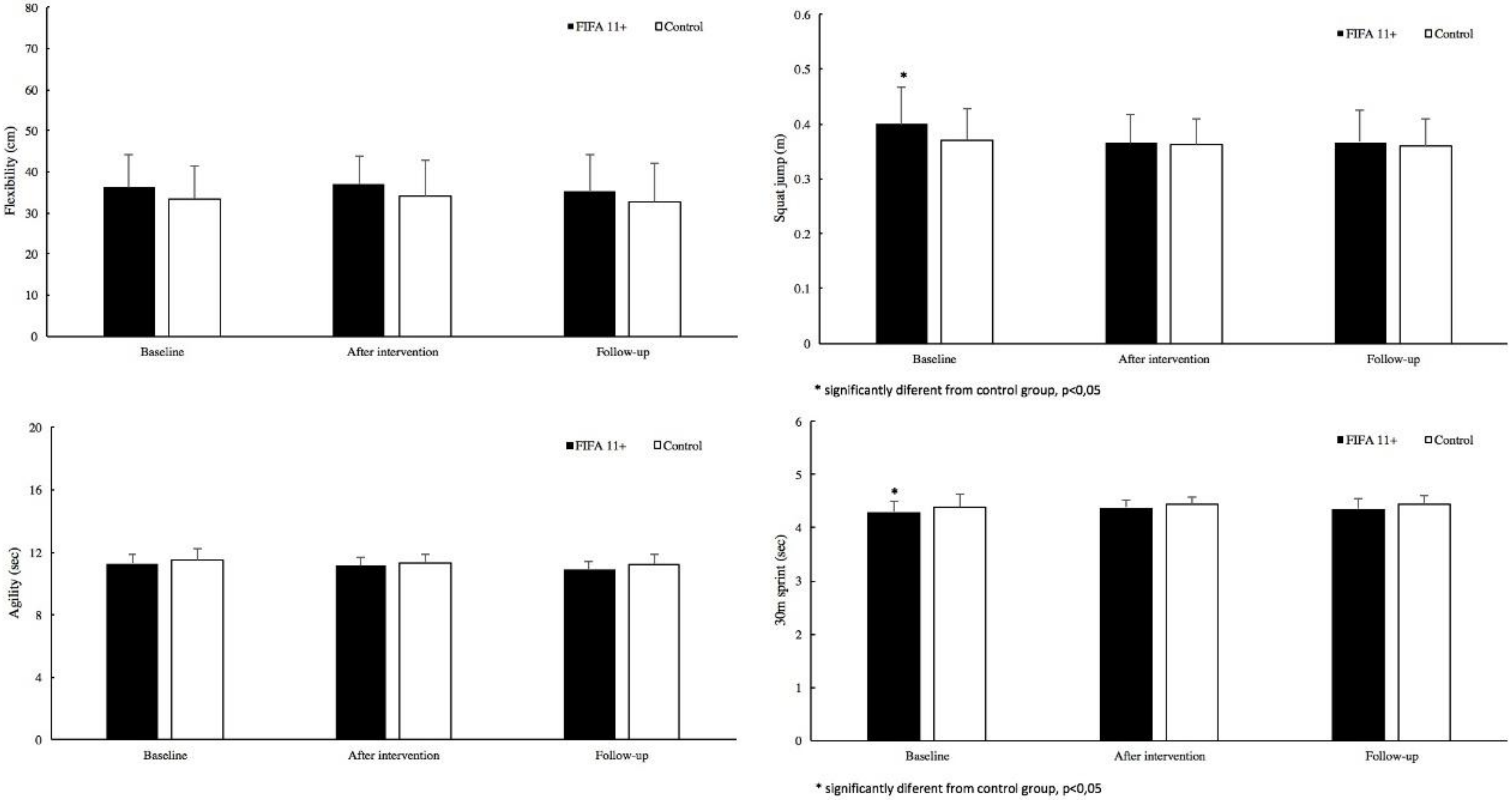

Figure 2. Effects of the intervention and follow-up on the outcome measures.

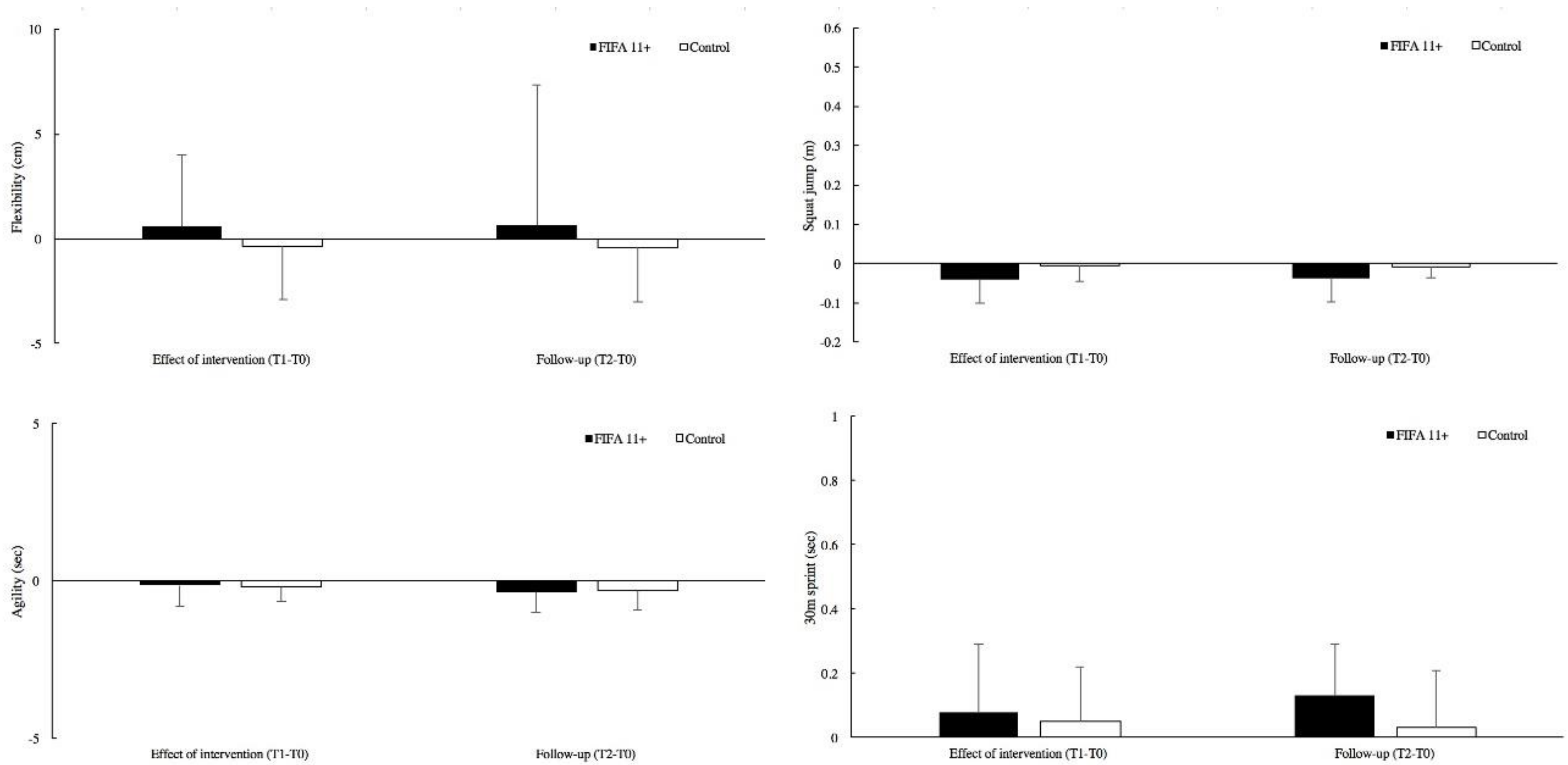

Figure 3. Mean differences and standard deviation, in group FIFA 11+ and Control, for intervention and follow-up periods.

STUDY II

Balance and proprioception responses to FIFA 11+ in amateur futsal players: short and long-term effects

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Submitted.

Balance and proprioception responses to FIFA 11+ in amateur futsal players: short and long-term effects

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Declarations of interest: none.

Authors Contributions: ML designed the study, carried out the field study, processed research data and drafted the manuscript; SL helped to process research data; TP helped to process research data; FA helped to perform the statistical analysis; MR helped to carry out the field study and helped to process research data; RC helped to carry out the field study; JO participated in the design and coordination of the study and helped to draft the manuscript; FR participated in the design and coordination of the study, helped to carry out the field study, helped to process research data, performed the statistical analysis and helped to draft the manuscript.

All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing Interests: None of the authors declare competing financial interests.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ABSTRACT

BACKGROUND: The FIFA 11+ has shown effects on balance and proprioception parameters in football players of different age groups and different sport levels, however not much has been studied in futsal. Accordingly, we examined the short and long term effects of the FIFA 11+ on static and dynamic balance, as well as proprioception in male amateur futsal players.

METHODS: A total of seventy-one male futsal players from six amateur clubs were enlisted and randomized to a group that was submitted to the FIFA 11+ program, performed during the warm-up (n=37, age: 27.33±4.33 years), or a control group submitted to regular warm-up (n=34, age: 25.55±4.65 years). The intervention endured 10 weeks, 2 sessions per week, succeeded by a 10-week follow-up period, in which both groups performed regular futsal warm-ups. For balance testing we selected the single legged postural sway with a force platform (static balance) and the Y balance test (dynamic balance) and for proprioception, active joint position sense testing.

RESULTS: Complete pre-post intervention and follow-up tests were available for 61 players. FIFA 11+ group showed higher training exposure and lower body mass index and body weight. After adjustment for the baseline differences, not significant differences between groups were observed in the pre-post changes for centre of pressure (CoP) measures, Y-balance and proprioception parameters both at short and long-term.

CONCLUSIONS: Performing FIFA 11+ for 10 weeks did not improve static and dynamic balance as well as proprioception in amateur futsal players.

Keywords: warm-up, futsal, joint position sense, postural sway, performance, centre of pressure, injury prevention.

1. INTRODUCTION

Literature regarding injury prevention, directs prevention to different features of sports practice, like strength, flexibility and neuromuscular training. Based on these aspects, during the past years, there have been many proposals for exercises to prevent injuries, with a great deal of variability as to, the injuries to be prevented, type of exercise, frequency, intensity and volume [1–3].

The "11+" program of the Fédération Internationale de Football Association (FIFA) seems to be the most widespread program aimed at the prevention of injuries at the moment [2]. Created for football, the “11+” did not fail to attract attention in other modalities, such as basketball [4] and futsal [5]. According to FIFA's Medical Assessment and Research Centre (F-MARC), football practice requires different skills and capabilities, including endurance, agility, speed, and technical and tactical knowledge of the game [6]. Futsal may share similarities with football, but does not withhold its particularities; futsal practice requires a smaller number of players on each side. As the pitch is almost eight times smaller than a conventional football pitch with reduced-size goals, playing this game requires skilful, creative play with accurate technical execution [6] making it a very physically intense sport [7]. Even though there may be variation in physical fitness amongst players of both modalities [8], the injury risk and the location of injuries may be somehow similar [9,10]. Acknowledging the similarities and differences between football and futsal and the key elements in FIFA´s injury prevention program, the program may contribute to the injury prevention requirements of futsal players also. To our knowledge, the only study with FIFA’s 11+ applied on futsal [5] revealed performance enhancements in balance, agility, sprint, isokinetic muscle strength and jump tests of youth futsal players, presupposing the reduction of the risk of injury. The improvement of balance was speculated to be one of the conditions for this injury risk reduction. Balance and proprioception enhancements have been explored due to the belief that they may reduce the risk of injuries [11–13]. In fact, many injury prevention programs have been object of consideration to study the effects on static balance [14–16], dynamic balance [15–17] and proprioception [2,14,18,19]. Specifically, the effects of the FIFA 11+ have also focused static and dynamic balance and proprioception, mainly on football players [20]. Consequently, it is of interest to test the effects of the FIFA 11+ on senior amateur futsal players. Thus, this study aims to analyse the short and long-term effects of the FIFA 11+ on balance and proprioception of amateur futsal players. Based on current literature, we hypothesize that performing the FIFA 11+ for 10 weeks may induce gains on balance and proprioception in futsal players as it has been verified in football players and that the gains may endure in the 10-week follow-up period after intervention.

2. MATERIAL AND METHODS

2.1. Participants

Requests for collaboration were sent by e-mail to all amateur senior male futsal teams competing in the Football Associations of Coimbra and Aveiro, Portugal. Twenty-four, out of the thirty-four teams invited, answered our request. Subsequently, study details were described by the researcher to the directors, managers and players of the clubs. A period of four weeks was given to obtain full consent of the club. Following this period, fourteen teams endorsed participation in the study. The main reasons assumed for declining participation were: no interest in changing sports practice routines and transportation difficulties for attending the laboratory assessments at the University. Randomly six teams were selected and randomly allocated by a blinded assistant into two groups: control (3 teams) and FIFA 11+ (3 teams).

The players of the six teams were submitted to eligibility criteria. The inclusion criteria for this study were: 1) male amateur futsal players competing in the Official Regional Amateur Futsal Championships of the Districts of Aveiro (1st and 2nd division) and Coimbra (unique division) of the Portuguese Football Federation, 2) players aged ≥ 18 years, 3) players that did not have contact with the FIFA 11+ in past years, 4) attendance to at least 2 training sessions per week plus match (excluding players that had less training sessions due to work or education commitments which can be usual in amateur teams). The exclusion criteria were: 1) players which interrupted training due to a serious time loss injury (3 weeks or more) or other less time consuming injuries that occurred in the course of the evaluation period; 2) players that suffered health problems during the study period, that could affect research parameters as well as those whose suspension or reintegration to the sport activity overlapped with the assessment period and could lead to bias of the results. 3) Additionally, players who changed club during the study period or those in the intervention group who failed to attend to at least 80% of the FIFA 11+ sessions were excluded from the analysis. Written informed consent was provided by the participants and all procedures were handled according to the Declaration of Helsinki. The study obtained approval from the ethics committee of the Faculty of Sport, University of Porto.

2.2.Procedures

2.2.1. Study design and randomisation procedures

This study was a parallel, two-group, stratified randomised controlled study. The fully eligible teams that participated in the study were randomized and assigned (allocation ratio 1:1) by a blinded assistant, without any affiliation or acknowledgment of the teams, to the control and experimental groups. Randomization proceedings took place by selection of one of two sealed, non-translucent, envelopes containing the group distribution. All participants, were tested at 3 moments: baseline (T0), after the 10th full week of intervention (T1), and after a 10-week follow-up period, where both groups used normal warm-up routine (T2). At each moment, the participants were submitted to the following testing procedures: static balance with a force platform (single legged postural sway), dynamic balance (Y-balance test) and knee joint proprioception (active joint position sense). Data collection forms, definitions and procedures used in this study, prevail in agreement with international consensus guidelines for injury surveillance [21].

2.2.2. Settings and locations where the data were collected

The research was conducted in Portugal (Aveiro and Coimbra), during the futsal championship of 2014/15. The testing took place in the Human Movement and Rehabilitation Laboratory of the School of Health Sciences of the University of Aveiro and in the teams own sports hall. The study initiated in September 2014 with the baseline measurements and ended in February, 2015. The time frame of the study was selected so that it would be complete before approximation of the ending of the championship.

2.2.3. Interventions

The coach and one or two players (normally the captain and sub-captain of the team) of the intervention teams were selected to administer the FIFA 11+ during the warm-up, with former formation guaranteed by the researcher. The coach was selected as the key element to administer the program to reassure a better rate of compliance of the players towards the program [22,23]. Paper and video support was prearranged for the participants in the experimental group. All teams initiated in level 1, and evolved to level 2 in three weeks as foreseen in the FIFA 11+ manual [23], meaning that all teams had 4 weeks of

FIFA 11+ in level 3. The FIFA11+ was executed twice a week as it was referred as the minimum recommended frequency to collect the proclaimed effects of the program, during 10 weeks. The averaged 20 minutes for conducting the FIFA 11+ matched the average time to accomplish the regular futsal warm-up of the control group. The warm-ups of the 3 teams in the control group were similar, integrating a combination of running, ball and dynamic stretching exercises consummated progressively in speed and intensity. The researcher and an assistant visited the teams on a regular basis to ascertain the correct execution of the program. The presence of the players and the frequency of sessions were recorded on predefined data collection forms.

2.2.4. Outcome measures

Player's baseline characteristics as player´s position, age, dominant leg and details of previous major injuries of all the players were recorded with a pre-designed questionnaire [21]. Body weight was obtained with the body composition analyser (seca mBCA 515, Seca, Birmingham, UK) and the height of the players with the digital stationary stadiometer (seca 264, Seca, Birmingham, UK).

For each testing protocol, all participants received verbal directives and visual demonstrations from the examiner. All the tests were performed in the beginning of the week, after a 48h period rest post-match, and before the training session.

2.2.4.1.Balance (static and dynamic)

Static balance was determined by assessing postural sway using a 600 X 400 mm force platform (AMTI BP400600-2000, AMTI, Watertown, MA, USA). Postural sway assessments were accomplished with bare feet, allowing three practice trials before testing [24]. Participants were asked to perform six valid single-leg stance trials of 30s (3 in each leg), with a 15s resting period in-between. The test required standing in the middle of the force platform, single-legged as still as possible, with the knee at full extension, looking forward at an eye-level marking on the wall, with hands kept on their hips. A mistrial was considered if the subject displaced his standing leg, touched the floor or touched the standing leg with the contra-lateral leg or if a hand was used to regain balance. Collected data was sampled at 1000 Hz. A Vicon Giganet using Vicon Nexus 1.8.5 software (Vicon Motion Systems Ltd, Oxford, UK) collected the 3 orthogonal force and moment components in three axis (X, Y and Z). The centre of pressure (CoP) data was low-pass filtered (10 Hz cut-off; 4^{th}-order Butterworth; bidirectional) and a custom-made Matlab® R2014a (MathWorks, Madrid, Spain) routine was applied to calculate the sway area (CoP Area - 95% confidence ellipse), total CoP displacement (Total CoP), CoP maximum displacement in the medio-lateral (CoPy) and antero-posterior (CoPx) directions, and CoP velocity.

2.2.4.2.Y-balance test

The Y-balance test is a simple, reliable, test to measure dynamic balance that was developed to standardise the modified Star Excursion Balance Test; and has shown very good levels of reliability (ICC ranging from 0.80 to 0.9) [25,26]. First, the Y-balance test was demonstrated, followed by four practice trials before the effective assessment trials took place [27]. The testing was performed with the subject standing with the heel of the bearing foot in the centre of the grid, maintaining the base of support. The subject was requested to slide the box reaching as far as possible and return back to the initial upright position without losing balance in the three testing directions. The assessor recorded the distances that the subject reached after each of the three effective assessment trials. As the heel was aligned with the middle of the grid, the foot length was subtracted in the anterior reach distance, avoiding re-alignment of the foot during the testing procedure [24]. The trial was discarded, requesting for an additional trial, if the subject rested the foot or gained balance touching the floor, lost balance, if the bearing foot was lifted or moved and if the subject failed to return the reaching foot to the starting position [24,28]. The reach distance was normalized to the subject's leg length (anterior superior iliac spine to inferior medial malleolus) providing a measure of performance [29]. The composite reach distance was obtained by summing the greatest reach distance from each direction giving the overall performance of the test. The best trial of each direction was considered for analysis.

2.2.4.3.Proprioception

Proprioception was assessed by determining knee joint position sense in the dominant lower limb, i.e. the leg the subject would kick a ball. Knee position sense was assessed with an ipsilateral technique of active joint positioning in open kinetic chain without visual input as previously reported [30].

Before the assessment, four 10mm reflective markers were fixed with double-sided adhesive tape to the skin of the apex of the greater trochanter, iliotibial tract level with the posterior crease of the knee when flexed to 80º, neck of fibula and prominence of the lateral malleolus. The markers represent the axis of the thigh and the leg. The subjects were seated in a comfortable position on a treatment table with the legs hanging freely but not touching the ground; they were requested to place their hands on the anterior face of the thighs during all trials. The proprioception protocol was previously demonstrated and individually explained to each subject before execution. Each subject repeated the protocol for familiarization as often as needed until he fully understood the test. Subsequently, each participant performed three trials in order to reproduce one target angle (between 40° and 60° of knee flexion) as previously described [31,32]. In brief, the subject was requested to freely extend his knee from the starting position (90º degrees of knee flexion) until the assistant requested to stop the movement in the test position (knee angle between 40° and 60° of flexion) [30]. The position was held for 3 seconds so that it could be memorized. After memorizing the target position, subjects then returned the knee to the starting position and were requested to reproduce the previously memorized position for three consecutive times, holding the target position for 3 seconds to guarantee a stable position for posterior analysis.

A sequence of 10 photographs of the target and the repositioning joint positions were taken with a digital camera that was attached to a tripod positioned at the level of the knee joint and at a 4-meter distance from the subject. To minimize camera tilt, the edges of the viewfinder were aligned in a parallel manner to the natural vertical and horizontal lines of the videotaped environment. Consequently, the knee angle was obtained with the Posture Assessment Software (SAPO)[33] and the succeeding parameters were calculated: relative error was calculated as the mean difference between the target position and the response positions (allowing analyses for directional bias); absolute angular error was calculated as the absolute difference between the target position and the attempt for reposition of the target; and the variable angular error, considered as the standard deviation from the average of the relative errors. This method of knee position sense assessment showed an ICC = 0.910, a standard error of measurement = 0.42 degree, smallest real difference = 1.16 degrees in football players [32].

2.3. *Data analysis*

Statistical analyses were performed on SPSS version 24.0 (SPSS Inc., Chicago, IL, USA). The normality of data distribution was tested with the Shapiro-Wilk test. Descriptive statistics were used to calculate the mean and standard deviation (SD). The independent

T-test was used to compare participants' characteristics between groups at baseline. For each outcome was computed the difference between post-intervention and baseline (short-term effect) and between follow-up and baseline (long-term effect). Crude and Adjusted Beta (β) and respective 95% confidence intervals (95% CI) were used to estimate the short and long-term effects of FIFA 11+ program. Statistical significance was established at $p < 0.05$ for all tests.

3. RESULTS

From the 91 futsal players who agreed to participate in the study, 20 did not fulfil the inclusion criteria. Subsequently, a total of 71 players participated in the study, being allocated to the FIFA 11+ (n=37) and the control group (n=34). Eleven participants dropped out after the baseline assessments; the flow diagram is displayed in Figure 1.

At baseline the FIFA 11+ group presented a lower body weight ($p = 0.03$), lower body mass index ($p = 0.04$) and a higher number of training sessions per week ($p < 0.001$) (Table 1). The weekly average of FIFA 11+ exposure was 1.9 ± 0.1 sessions.

There were no significant differences for baseline characteristics between players who participated in follow-up testing and the players who dropped out.

3.1.Effects on static and dynamic balance

The results of the effect of the FIFA 11+ on postural sway revealed, no significant difference in the change of any CoP parameters following intervention for both lower limbs before and after beta adjustment for group characteristics and training exposure (Table 2). Significant differences were found in the follow-up period (long-term effect) for the total CoP of the dominant lower limb [Crude β, -19.43 (-33.78; -5.08)] and for the CoP velocity of the dominant lower limb [Crude β, -0.68 (-1.17; -0.18)], however, after adjustments to baseline group differences, the significance for both parameters fell out of range [Adjusted β, -5.83 (-33.09; 21.43); -0.21 (-1.14; 0.73)] respectively (Table 2).

The outcomes of the effect of the FIFA 11+ on the Y-balance test showed statistical significance for the posteromedial reach of the dominant lower limb after intervention [Crude β, 3.20 (1.04; 5.35)], however failed to maintain significance after adjustment for group characteristics and training exposure [Adjusted β, 1.74 (-2.23; 5.72)] (Table 2).

3.2.Effects on joint position sense

No differences were found in the absolute angular error for proprioception (Figure 4), in pre-post intervention (immediate effect), neither after the 10-week follow-up (long-term effect) before [Crude β: 0.29 (-0.52; 1.10); -0.16 (-1.13; 0.81)], respectively, and after adjustments for group characteristics and training exposure [Adjusted β: -0.20 (-1.70; 1.31); -0.55 (-2.45; 1.40)] (Table 2). The same pattern was maintained for the relative angular error at short [Crude β: -0.65 (-1.96; 0.67); Adjusted β: -1.15 (-3.68; 1.38)] and long-term [Crude β: -0.45 (-2.02; 1.11); Adjusted β: -0.59 (-3.58; 2.39)] as well as for the variable angular error both at short [Crude β: 0.04 (-0.36; 0.44); Adjusted β: -0.40 (-1.11; 0.30)] and long-term [Crude β: 0.06 (-0.36; 0.49); Adjusted β: -0.39 (-1.09; 0.31)] (Table 2).

4. DISCUSSION

The purpose of this study was to evaluate the short and long-term effects of the FIFA 11+ program on static and dynamic balance and knee joint position sense amongst amateur futsal players. Our results did not support our hypothesis that performing FIFA 11+ for 10 weeks can improve balance and proprioception and that the gains would persist 10 weeks after the intervention.

To our best knowledge, no study involving the FIFA 11+ tested static balance with the force platform, however, the lack of significant results after intervention may be considered in agreement with a recent study [34]. In this study, Ghareeb et al. implemented the FIFA 11+ and a new warm-up program (NWP) in 34 male high school football players (age = 16.53 ± 1.08 years) during 6 weeks (3 sessions/week). Only the NWP showed improvement in the Athlete Single Leg Stability Test protocol assessed with the Biodex Balance System SD. Although this study pointed out lack of improvements in this area, the majority of the FIFA 11+ related studies have shown positive results with other static or quasi-static balance tests. Daneshjoo et al. [35] in a study involving 36 male (< 21 years) professional football players, achieved significant gains in static balance after 2 months (24 sessions of FIFA 11+), using the stork stand balance test on the dominant leg, with eyes closed and eyes opened; Dunsky et al. [36] revealed that the implementation of the "FIFA 11+" 3 times per week, during 6 weeks improved the results of the static balance of 13 year old football players (FIFA 11+ = 10; control = 10). Steffen et al. [37] applied different delivery methods of the FIFA 11+ in 31 teams of 13 to 18-year-old female players of 3 different competition levels. The testing was carried out with time recording (in seconds) as each participant stood single-legged, eyes-closed, balanced on a balance pad. The 78 players included in the intervention group with the highest adherence to the FIFA 11+ (average 2.2 sessions/week) revealed significant improvements in balance after adjustment for cluster, age group and playing level. However, the group with low adherence to the FIFA 11+ intervention (1.5 session/week), did not show significant gains. The same study also tested dynamic balance and observed, after the adjustment for age group, playing level, previous injury history and clustering effects, a significant higher anterior reach of the lower limb.

Other studies also found significant improvements in some dynamic balance parameters. For instance, Ayala et al. [38] showed significant improvements in the anterior and posteromedial reach distance of the Y-balance test after 4 weeks (3 sessions/week) in the FIFA 11+ group in their study with 41 youth male amateur football players. Conversely, Impellizzeri et al. [39] enrolled 81 players for their study in which during 9 weeks, the intervention group (42 players) were submitted to the FIFA 11+ 3 times a week. No changes in the composite score of the star excursion balance test was observed. Although Daneshjoo et al. [35], showed significant improvements in the static balance testing, as referred above, the dynamic testing using the star excursion balance test, did not reach statistical significance with the composite scoring method as well.

To our best knowledge, as the only study that was conducted relating futsal and the FIFA 11+ revealed improvements in the reduction of number of falls by 30% of youth futsal players in the single-legged flamingo balance test [5], we also expected to observe positive effects on static balance in our players as their average number of sessions in the 10 weeks of intervention reached 1.8 sessions/week. However, the controversial results verified around balance may be related to characteristics of the participants as age and BMI, the training conditions, the competition level as the number of total training sessions per week and possibly the extent of the period of the FIFA 11+ intervention. As above-mentioned, Steffen et al. [37] observed a dose-response relationship over the course of the 4 month season with athletes who had a weekly frequency of 2.2 FIFA 11+ sessions (30-40% higher participation rate), compared to players with a lower participation rate [37], leaving into to consideration that a higher weekly frequency or a longer intervention period may be necessary to observe significant effects.

As one of the key elements in the development of the FIFA 11+ is neuromuscular control and balance [23], the improvements shown for static balance before adjustments for the total

CoP and the CoP velocity of the dominant lower limb in the follow-up period and after adjustments in the CoPx of the dominant lower limb may lead us to expect that a longer intervention period would probably have shown significant effects right after intervention.

The FIFA 11+ refers as a key point, the proceeding with proper technique during the execution of exercises, as in continuous correction of posture maintaining adequate body control, as in straight leg alignment, knee-over-toe position and soft landings [23]. By these means we considered that it would be adequate to analyse proprioception. To our best knowledge, only one study included proprioception assessment (joint position sense testing) in all FIFA 11+ related studies analysed, although their results do not agree with the results of this study. Daneshjoo et al. [35] used the isokinetic dynamometer to actively assess joint position sense at 30º, 45º and 60º of knee flexion. They verified significant differences at two target angles (45º and 60º). Interestedly, our target angles were closer to the last two angles that revealed significance. However, the lack of results observed in our study may be due to the fact that our players, from both groups, showed a very high accuracy (low angular error) at baseline, possibly making improvement more difficult. The mean of absolute error in the dominant leg observed in the Daneshjoo et al. study was 4.7º, 4.5º and 4.2º at 30º, 45º and 60º, respectively, per comparison with an error of 1.8º and 1.9º observed in our 11+ and control group, respectively. Given the importance of proprioception in injury prevention, it would be essential to deepen this topic with different forms of proprioception testing.

Some study limitations should be acknowledged. A limitation of our study may be associated to the fact that the participants were not blinded to control/intervention which may lead to special motivational efforts or to create expectations generated by the admission to intervention group. Also, we registered significant group differences as in weight, BMI and training exposure, however, the statistical methods of beta adjustments, were defined to overcome these baseline differences so that the two groups would be comparable. Another limitation is related with the fact that all testing was executed in post-work schedule, because all players were amateurs, and there is no possibility to control for the work efforts; so the physical or mental effort of the day of work may have had influence on parameters evaluated.

5. CONCLUSION

Performing FIFA 11+ for 10 weeks did not improve, after intervention, static and dynamic balance as well as proprioception in amateur futsal players. Potential benefits in static balance for amateur futsal teams may occur in higher weekly interventions.

Acknowledgements

We would like to acknowledge Mr Norberto Rei for his supportive involvement during the research experiment. We would also like thank the commitment and dedication of all players, coaches and sports staff, and all technical supporting personnel, which made this study possible. The European Regional Development Fund through the Operational Competitiveness Program, and the Portuguese Foundation for Science and Technology (FCT) support the research unit CIAFEL (REF: UID/DTP/00617/2013). iBiMED is a research unit supported by the Portuguese Foundation for Science and Technology (REF: UID/BIM/04501/2013) and POCI-01-0145-FEDER-007628 funds.

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Figures

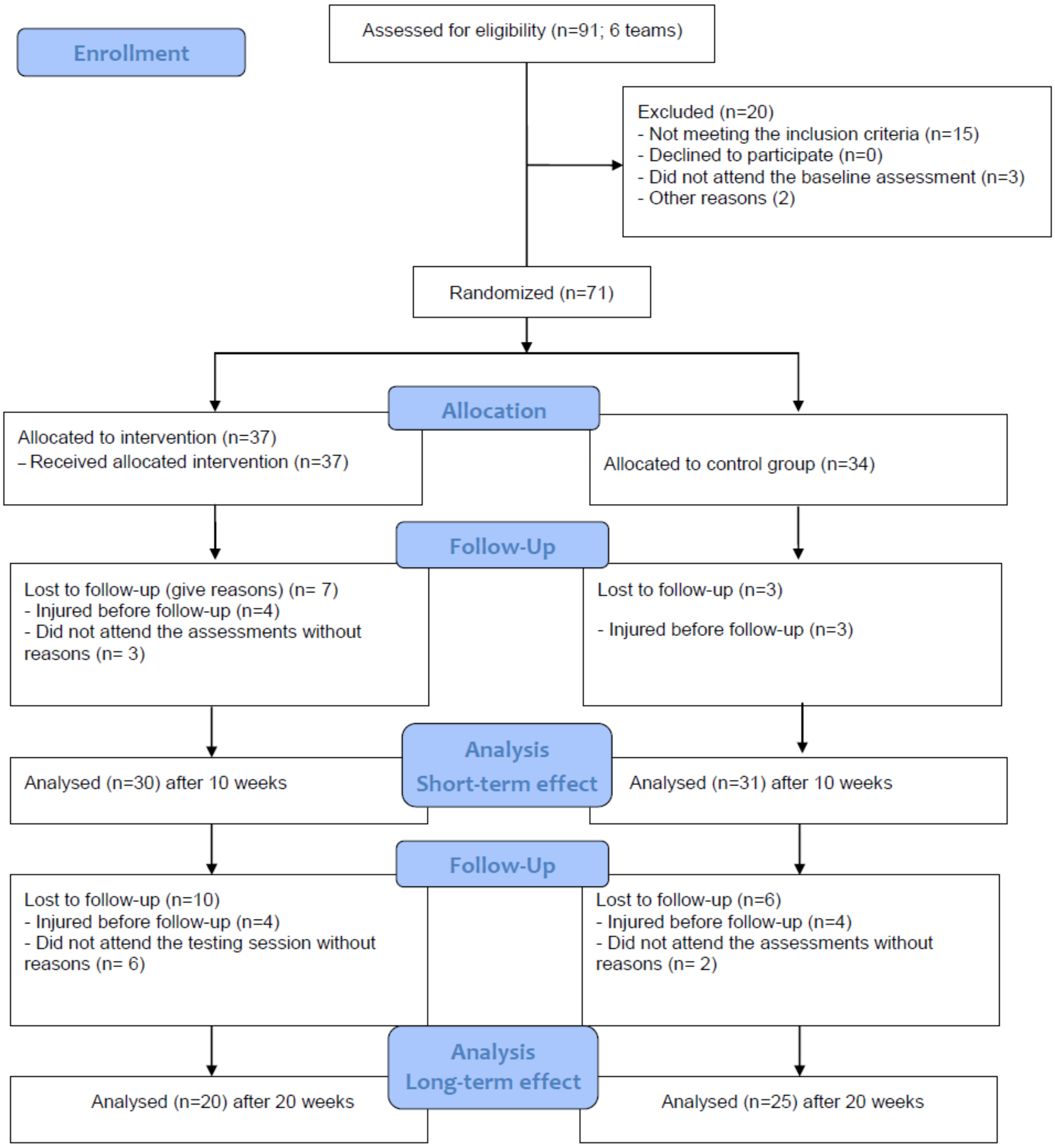

Figure 1. Flow-chart depicting the study design.

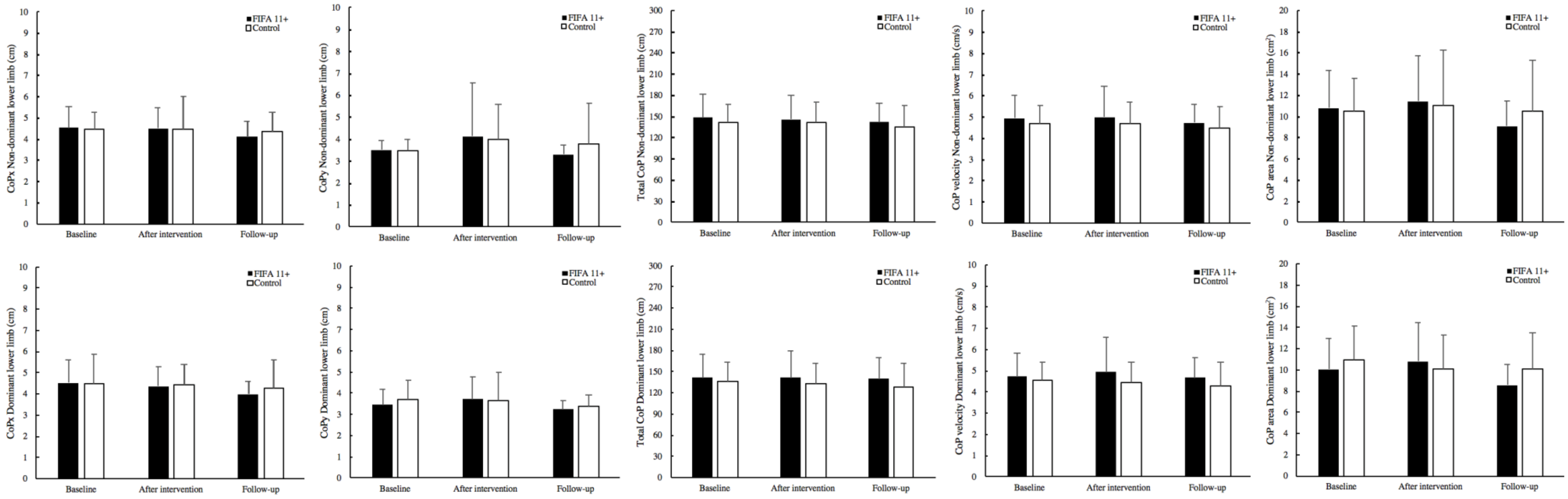

Figure 2. Postural sway at baseline, after intervention and at follow-up.

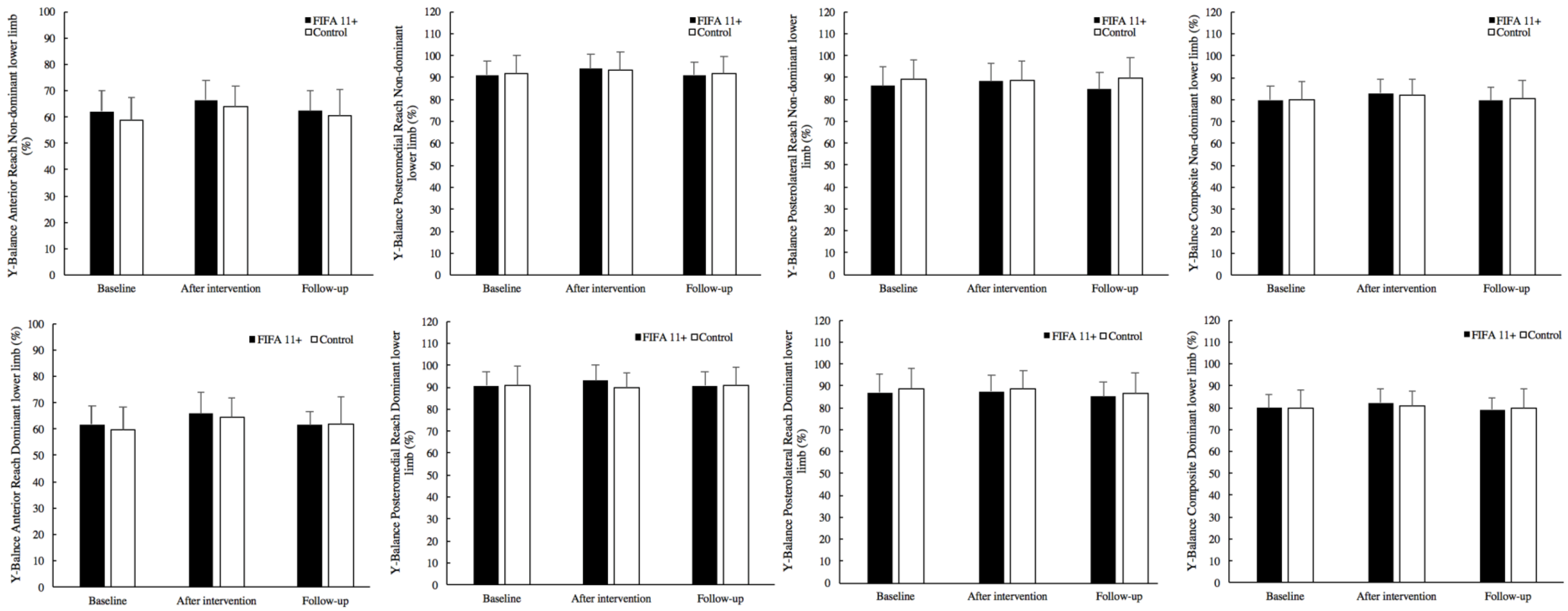

Figure 3. Dynamic balance (Y-balance test) at baseline, after intervention and at follow-up.

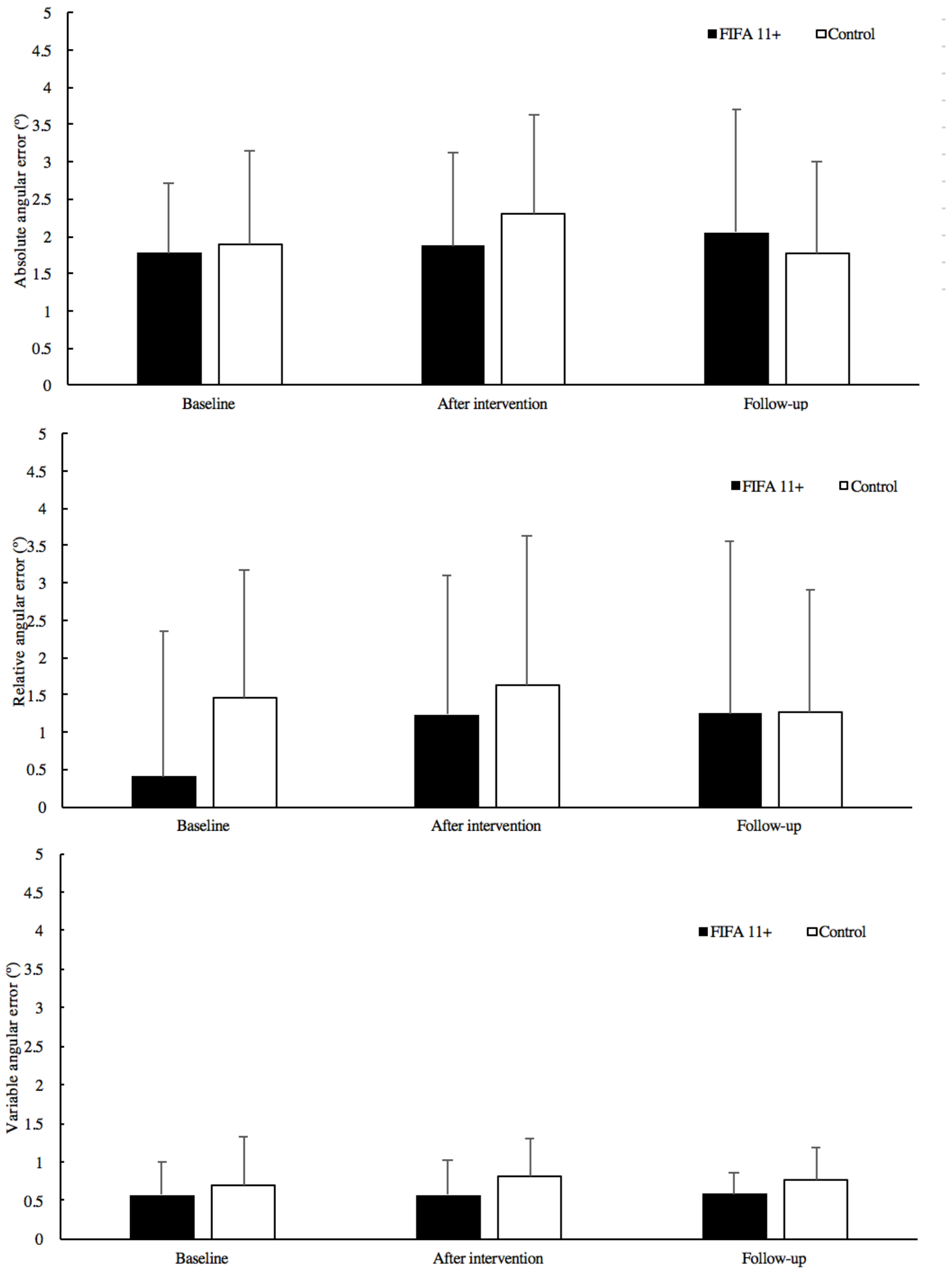

Figure 4. Joint position sense at baseline, after intervention and at follow-up.

Tables

Table 1. Baseline characteristics of the players stratified by group (mean ± SD).

	FIFA 11+	*Control*	*P value*
Age (years)	27.33 ± 4.33	25.55 ± 4.65	0.13
Weight (kg)	73.25 ± 9.82	78.77 ± 9.45	**0.03**
Height (cm)	175.12 ± 7.11	176 .83 ± 6.33	0.33
Body Mass Index (kg/m^2)	23.82 ± 2.36	25.17 ± 2.57	**0.04**
Training exposure from T0-T1 (sessions/week)	2.74 ± 0.18	1.85 ± 0.42	**<0.001**
Training exposure from T0-T2 (sessions/week)	2.60 ± 0.30	1.80 ± 0.36	**<0.001**
Training exposure from T1-T2 (sessions/week)	2.45 ± 0.60	1.80 ± 0.37	**<0.001**
Postural sway			
CoPx Non-dominant Lower Limb (cm)	4.52 ± 1.01	4.49 ± 0.75	0.92
CoPx Dominant Lower Limb (cm)	4.51 ± 1.09	4.50 ± 1.37	0.98
CoPy Non-dominant Lower Limb (cm)	3.51 ± 0.45	3.48 ± 0.51	0.82
CoPy Dominant Lower Limb (cm)	3.44 ± 0.73	3.72 ± 0.88	0.20
Total CoP Lower Non-dominant Limb (cm)	148.22 ± 32.88	140.95 ± 26.03	0.35
Total CoP Lower Dominant Limb (cm)	141.40 ± 32.90	136.49 ± 26.85	0.53
CoP Velocity Lower Non-dominant Limb (cm/s)	4.94 ± 1.10	4.69 ± 0.85	0.33
CoP Velocity Lower Dominant Limb (cm/s)	4.71 ± 1.10	4.53 ± 0.86	0.47
CoP Area Non-dominant Lower Limb (cm^2)	10.81 ± 3.48	10.50 ± 3.09	0.72
CoP Area Dominant Lower Limb (cm^2)	10.06 ± 2.87	10.89 ± 3.22	0.31
Y-balance test			
Anterior Reach of the Non-dominant Lower Limb (%)	62.05 ± 7.92	58.89 ± 8.72	0.14
Anterior Reach of the Dominant Lower Limb (%)	61.86 ± 6.84	59.62 ± 8.89	0.28
Posterolateral Reach of the Non-dominant Lower Limb (%)	86.31 ± 8.46	89.04 ± 9.20	0.23
Posterolateral Reach of the Dominant Lower Limb (%)	87.06 ± 8.37	88.52 ± 9.32	0.52
Posteromedial Reach of the Non-dominant Lower Limb (%)	91.11 ± 6.16	91.88 ± 8.17	0.68
Posteromedial Reach of the Dominant Lower Limb (%)	90.77 ± 6.46	90.89 ± 8.57	0.95
Composite Reach of the Non-dominant Lower Limb (%)	79.83 ± 6.51	79.94 ± 8.11	0.95
Composite Reach of the Dominant Lower Limb (%)	79.89 ± 6.20	79.68 ± 8.60	0.92
Proprioception (Joint Position Sense)			
Absolute Angular Error (º)	1.78 ± 0.94	1.90 ± 1.26	0.68
Relative Angular Error (º)	0.41 ± 1.94	1.46 ± 1.71	0.30
Variable Angular Error (º)	0.58 ± 0.41	0.70 ± 0.62	0.41

Table 2. Short and long-term changes in static and dynamic balance and proprioception.

	FIFA 11+ Group				Control Group			
	Short-term Effects		*Long-term Effects*		*Short-term Effects*		*Long-term Effects*	
	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant
Postural sway								
CoPx (cm)	-0.03±1.34	-0.25±1.36	-0.34±0.82	-0.70±1.19	-0.04±1.62	-0.09±1.34	-0.05±1.05	-0.14±1.33
CoPy (cm)	0.59±2.21	0.24±1.00	-0.23±0.54	-0.40±0.68	0.50±1.59	-0.07±1.68	0.25±1.95	-0.15±0.53
Total CoP (cm)	-10.99±38.68	- 11.70±42.23	-19.65±29.75	-25.93±30.53	-0.06±25.37	-3.81±23.19	-5.61±21.47	-6.50±17.34
CoP Velocity (cm/s)	-0.21±1.31	-0.18±1.28	-0.66±0.99	-0.86±1.02	0.02±0.85	-0.10±0.76	-0.18±0.71	-0.19±0.64
CoP Area (cm^2)	0.56±5.77	0.47±3.83	-1.41±2.54	-1.67±2.17	0.52±5.76	-0.85±3.70	0.44±5.10	-0.26±3.36
Y-balance test								
Anterior Reach (%)	4.33±5.92	3.92±4.34	2.50±4.95	1.65±4.55	4.91±5.75	4.65±6.01	2.24±6.98	2.68±6.77
Posterolateral Reach (%)	1.85±5.08	0.53±4.31	0.96±6.23	0.38±5.42	-0.58±8.07	-0.06±6.12	0.26±5.50	-1.81±5.54
Posteromedial Reach (%)	2.86±3.12	2.21±3.78	2.35±6.22	2.10±4.57	1.51±5.14	-0.99±4.58	0.01±4.15	0.56±6.02
Composite Reach (%)	3.01±3.60	2.22±2.63	2.20±3.12	1.39±3.19	1.95±4.77	1.20±4.55	0.72±3.24	0.46±5.05
Proprioception (Joint Position Sense)								
Absolute Angular Error (º)	________	0.11±1.43	________	0.05±2.05	________	0.40±1.73	________	-0.11±1.42
Relative Angular Error (º)	________	0.83±2.73	________	0.36±3.53	________	0.18±2.45	________	-0.10±1.99
Variable Angular Error (º)	________	0.07±0.69	________	-0.01±0.50	________	0.11±0.87	________	0.09±0.76

*Comparisons performed using Linear Regression with adjustment for baseline differences

STUDY III

Effects of the FIFA 11+ on ankle evertors latency time and knee muscle strength in amateur futsal players.

Lopes, M., Rodrigues, J.M., Monteiro, P., Rodrigues, M., Costa, R., Oliveira, J., Ribeiro, F.

Submitted.

Effects of the FIFA 11+ on ankle evertors latency time and knee muscle strength in amateur futsal players.

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ABSTRACT

BACKGROUND: The FIFA 11+ has shown to increase muscle strength and reduce injury risk. The purpose of this study was to assess the short and long-term effects of the FIFA 11+ on knee strength, and the muscle latency after sudden inversion of amateur futsal players.

METHODS: Seventy-one male futsal players were recruited and randomized to a FIFA 11+ (n=37, age: 27.0±5.1 years) and a control group (n=34, age: 26.0±5.1 years). The FIFA 11+ program was executed twice a week, for 10 weeks, followed-up after 10 weeks where both groups executed regular warm-ups. Concentric and eccentric isokinetic knee muscle strength and latency time of the evertor muscles after sudden inversion of the ankle was executed with a trapdoor mechanism following an EMG protocol of selected leg muscles (peroneus brevis and peroneus longus) were evaluated.

RESULTS: No significant difference between groups for short-term changes in isokinetic strength after baseline adjustments were observed. At long-term, significant gains were obtained after adjustments in eccentric strength for both lower limbs as for the H/Q ratios for the dominant limb. No changes between groups were observed in the peroneus brevis and peroneus longus latency time.

CONCLUSIONS: Performing FIFA 11+ did not have short-term effects on knee strength and muscle latency after sudden inversion in amateur futsal players. However, significant long-term effects were observed for eccentric strength and H/Q ratios.

Key words: warm-up, injury prevention, ankle inversion test, latency time, isokinetic testing.

Introduction

Futsal may be similar to football, however it possesses its own specificities.The fast movements with sudden changes of direction, requires the need for quick decisions in a tight space, making the game attractive to more and more players around the world, as well as it has been seen of use, as a complement for training in 11-a-side football teams (FIFA 2015). Futsal is a very physically demanding sport. In fact, futsal is considered to be a multiple-sprints sport that implies more high-intensity phases than in football, in terms of proportion of match time (Barbero-Alvarez et al. 2008). The distinct components of futsal like the repetitive cycles of single-leg standing while dominating or protecting the ball from the opponents, may entail stress on the joints of the lower leg, predisposing the foot and ankle to injury (Cain et al. 2007). In fact, the ankle sprain is one of the most prevalent diagnoses when it comes to time-loss injuries in futsal (Junge & Dvorak 2010; Serrano et al. 2013).

The FIFA 11+ is an injury prevention program that does not require specific equipment for execution (Bizzini et al. 2011) and was designed combining key exercises from its predecessor “The 11” and the “Prevent Injury and Enhance Performance Program- PEP” (F-MARC 2015). The 11+, calls the attention of the factors known to be important in the prevention of knee and ankle injuries. To fulfil the program with proper execution techniques, the athlete has to be fully aware and focused on his body control, with the maintenance of good posture and correct body alignment in all moments (Bizzini et al. 2011; F-MARC 2015). Considering the high rate of ankle injuries in futsal and the importance of the ankle in the correction of posture and body alignment, we considered for testing the effects of the FIFA 11+ injury prevention program on the evertor muscles latency time after simulated sudden inversion.

Another key element of the FIFA 11+ is eccentric training of the hamstrings (Bizzini et al. 2011). It is widely known that hamstring strain injuries are one of the leading injuries in numeral sports (Opar et al. 2012). It is widely accepted that the causes for hamstring injury are multifactorial, being muscle weakness considered one of the causing factors (Mendiguchia et al. 2011; Opar et al. 2012). Considering futsal players have a higher acceleration capacity than football players, it may imply differences in the risk of injury of these athletes (Matos et al. 2008). Due to the high incidence of ankle sprains and muscle strains in futsal players, this study aimed to analyse the short and long-term effects of the FIFA 11+ on knee muscle strength and ankle evertor muscles latency time after simulated sudden inversion in amateur futsal players.

Methods

Study design and randomisation procedures

Study details are presented according to the CONSORT statement (Schulz et al. 2010).

This study was designed as a parallel, two-group, stratified randomised controlled trial (Figure1. Flow diagram). Randomization and allocation (allocation ratio 1:1) of the eligible teams was done by a blinded assistant, without any affiliation or recognition of the teams, to the control and intervention groups by selection of one of two sealed, opaque, envelopes containing the group allocation.

Player's position, age, stature, body mass and dominant leg, as well as, match and training time exposure, weekly training exposure, FIFA 11+ exposure were collected. All teams were tested for isokinetic knee muscle strength and latency time of the evertor muscles after sudden inversion of the ankle (simulating an ankle sprain) at baseline (T0), following 10 weeks of intervention (T1), and after 10 weeks of regular warm- ups of all teams (T2).

Participants

Invitations were sent via e-mail to the 34 amateur senior male futsal teams competing in the Football Associations of Coimbra and Aveiro, Portugal. Details of the study were explained by the researcher to the managers and players of the clubs to the 24 teams that declared interest to partake in the study. Full consent of 14 teams (including players, managers and directors consent) was acquired in four weeks. Participation was declined mainly due to transportation requisites to attend the Human Movement and Rehabilitation Laboratory of the School of Health Sciences of the University of Aveiro. Randomly 6 teams were selected and randomly allocated by a blinded assistant into two groups: control (3 teams) and intervention (3 teams) group "FIFA 11+". The selected players met the following inclusion criteria: 1) male amateur futsal players competing in the Official Regional Amateur Futsal Championships of the Districts of Aveiro (1^{st} and 2^{nd} division) and Coimbra (unique division) of the Portuguese Football Federation, 2) players aged ≥ 18 years, 3) players which did not have interaction with the "FIFA 11+" in previous years, 4) attendance to a minimum of 2 training sessions per week along with match (which excluded players with less training sessions due to career compromises which can be common in amateur teams).

The exclusion criteria were: 1) players which ceased training due to a serious time loss injury (≥ 3 weeks) or other less time consuming injury that emerged in the evaluation period, 2) players that experienced health issues during the study period, that could affect research parameters and those whose suspension or reintegration to the sport activity overlapped the evaluation period and could lead to bias of the results.

Written informed consent was obtained from all players and all procedures were conducted according to the Declaration of Helsinki. The study was approved by the ethical committee of the Faculty of Sport, University of Porto.

Interventions

The coach, supported by one or two players of the team (normally the captain and sub-captain), were selected to guarantee the delivery of "FIFA 11+". The formation of the intervention delivery agents was guaranteed by the researcher. The coach was selected as the key element to administer the program to reassure a greater rate of compliance of the players towards the program (Soligard et al. 2010; Bizzini et al. 2011). The players in the 3 intervention teams had access to paper and video support regarding the FIFA 11+ program. The 3 teams started in first level and evolved to the next level in three weeks, meaning that all teams had 4 weeks of FIFA 11+ in the third level. Considering that the teams were amateur, expecting a small weekly training frequency, it was defined to execute the FIFA11+, twice a week, as it is the recommended minimum to retrieve the proclaimed effects of the program (Bizzini et al. 2011). The average duration of the FIFA 11+ intervention of 20 minutes matched the average time of regular warm-ups of the control group. The warm-ups of the teams in the control group included a combination of running, ball and dynamic stretching exercises succeeded in progressive order of speed and intensity. The researcher and an assistant visited the teams on a regular basis to insure the correct delivery of the program.

Outcome measures

All subjects were submitted to the testing procedures with adequate sports clothing, shorts, t-shirt and training shoes. The tested subjects were not exposed neither to intensive training or matches in the 48 hours previous to the assessments. Each subject was screened so they would be free of current musculoskeletal or joint pain and discomfort.

Player's baseline characteristics

The baseline information collected included, player´s position, age, stature, weight, dominant leg and details of previous major injuries. Body weight was obtained with the body composition analyser (Seca mBCA 515, Seca, Birmingham, UK), the height of the players with the digital stationary stadiometer (Seca 264, Seca, Birmingham, UK), and body mass index (kg/m^2) was calculated.

Isokinetic testing

Isokinetic testing (Biodex System 3, Biodex Medical Systems Inc., New York, USA), was performed, by the same examiner, after adequate familiarization with the dynamometer. Before the protocol, the subjects performed a warm-up consisting 5 min of cycling in a mechanically braked cycle ergometer (Monark E-824, Vansbro, Sweden) with a fixed load corresponding to 50 watts, and also performed nine submaximal concentric contractions of the knee extensors and flexors, immediately followed by three maximal contractions. Standard procedures were accomplished for adequate seated positioning, body stabilizing and anatomical alignment of the tested limb (Biodex Medical Systems Inc 2002), as for gravitational correction and verbal encouragement throughout the isokinetic procedures (Croisier et al. 2008; Lehance et al. 2009; Fillyaw et al. 1986). The testing procedure included concentric contractions of both quadriceps and hamstrings at angular velocities of 60º/s (3 repetitions) and 240º/s (3 repetitions). Afterwards, eccentric strength of the hamstrings was tested at 30º/s (3 repetitions). The conventional and functional H/Q ratios were also calculated for the dominant and non-dominant limb. The starting limb was randomly selected. All sets of testing were separated by 1 minute of rest. The best result of each test was selected for calculation (Brito et al. 2010). The peak torque results were normalised for body weight (Nm/kg), allowing comparison of knee strength between players (Cameron et al. 2003). The functional H/Q ratio was calculated with the hamstrings eccentric peak torque at 30º/s and quadriceps concentric peak torque at 240º/s. The referred angular speeds have been used by other researchers in the assessment of muscle strength in football (Croisier et al. 2008; Lehance et al. 2009) and futsal players (Reis et al. 2013).

Sudden ankle inversion measurements

All subjects were familiarized with the trapdoor mechanism's function and the EMG protocol (Figure 1). Skin preparation and electrode placement followed SENIAM recommendations (www.seniam.org). A detailed description of the procedures used in this study can be found elsewhere (Correia et al. 2016). In brief, the trapdoor mechanism used in this study was custom made with a non-slip surface to submit each ankle of the subject, in a random manner, to a sudden movement of inversion in a 30º frontal plane (Figure 2). The testing stopped, once each subject completed 3 valid tests in each leg. The trapdoor was released randomly to inhibit the participant from anticipating the dropping as well as to discard pre-motor activity from the muscles being tested. The real-time analysis of baseline activity was assessed to prevent potential pre-motor response (Cordova et al., 2000a; Cordova and Ingersoll, 2003). EMG muscle activity was recorded using an EMG wireless system (Myon 320, myon AG, Schwarzenberg, Switzerland), with a sampling frequency of 1000Hz. The latency time was calculated with a specific mathematical routine implemented using GNU Octave 4.0.0 scientific programming language. The routine began by smoothing the rectified EMG signal through a 6th-order low pass Butterworth filter with a 50Hz cut-off frequency and then estimating the baseline EMG mean and SD amplitude during a time window of 250ms before the opening of the trapdoor. This signal then passed through moving-average filter with a 25ms sliding window, and the muscle EMG onset was determined as the instant where this average first surpassed 3 SD above the baseline mean and remained higher for at least another 25ms. Finally, the latency time was determined as the time elapsed between the opening of the trapdoor and the start of the first window above threshold. This algorithm is analogous to previously reported onset detection methods (Hodges & Bui 1996; Correia et al. 2016). A visual inspection of EMG trace adjacent to the zone of interest was also performed in order to prevent any errors of the EMG activity onset detection routine (Forestier & Terrier 2011).

Data Analysis

All analyses were conducted on SPSS version 24.0 (SPSS Inc., Chicago, IL, USA). Normality of data distribution was tested with the Shapiro-Wilk test. Descriptive statistics were used to calculate the mean and standard deviation (SD). The independent T-test was used to compare participants' characteristics between groups at baseline. For each outcome was computed the difference between post-intervention and baseline (short-term effect) and between follow-up and baseline (long-term effect). Crude and Adjusted Beta (β) and respective 95% confidence intervals (95% CI) were used to estimate the immediate and long-term effect of FIFA 11+ program. The significance level was set at $p < 0.05$.

Results

Of the total of 71 players which participated in the study, 37 were allocated to the intervention group and 34 to the control group. After baseline assessments, 13 players dropped out. There were no significant differences for baseline characteristics between players who did not participate in follow-up performance testing and the 13 players who dropped out. The flow diagram is displayed in Figure 1.

The FIFA 11+ group and control group presented baseline differences for body weight ($p=0.005$), body mass index ($p=0.024$) and number of training sessions per week (training exposure, $p<0.001$) (Table 1). The weekly average of FIFA 11+ exposure was 1.81 ± 0.28 sessions.

Effects on isokinetic testing

At baseline, the control group showed higher eccentric peak torque for the hamstrings of the non-dominant ($p=0.002$) and dominant limb ($p<0.001$), as well as higher H/Q conventional ratio for the dominant limb ($p=0.018$) and functional ratio for the non-dominant ($p=0.001$) and dominant limb $p=0.001$) (Table 2).

After the intervention, no significant differences were observed between in the changes on concentric peak torque of the quadriceps at 60º/s and 240º/s of angular velocity, for both limbs, before and after adjustments for baseline differences. At long term, the decrease in concentric peak torque at 60º/s of the quadriceps in the dominant limb was significantly higher in the control group when adjusted to baseline differences (Table 3 and Figure 3). For the concentric peak torque of the hamstrings at both 60°/s and 240º/s no statistical differences for short-term effects and long-term effects were observed between groups after adjustments for baseline differences.

Eccentric peak torque analysis revealed significant gains for crude analysis after FIFA 11+ program for both limbs, losing significance after adjustments (Table 3). At long-term the differences between groups (both limbs) remained significant, i.e. higher improvement in the FIFA 11+ group, even after adjustments.

Regarding the H/Q conventional ratio, a decrease of the H/Q conventional ratio of the dominant limb for the control group and an increase for the experimental group was observed at long-term after adjustments (Figure 4). After adjustments, the FIFA 11+ group showed a significant increase in the functional H/Q ratio of the dominant limb compared to the control group (Table 3).

Effects on evertor muscle delay in sudden inversion testing

At baseline, the delay of the peroneus longus of the non-dominant limb (p=0.002) was higher in the FIFA 11+ group. Differences close to the significant level set were also considered for adjustment procedures, i.e. the delay of the dominant peroneus longus (p=0.056) and the H/Q conventional ratio for the non-dominant limb (p=0.061) (Table 2). The analysis of muscle reaction delay change revealed significance for the short-term effects of the FIFA 11+ in the peroneus brevis of the non-dominant limb for crude analysis, losing significance after baseline difference adjustment (Table 4 e Figure 5). The same occurred for peroneus longus in the dominant lower limb. No effects occurred for long-term effect analysis.

Discussion

The purpose of this study was to evaluate the short and long-term effects of the FIFA 11+ on isokinetic strength and evertor muscles latency time amongst amateur futsal players. The main results indicated no significantly different in strength changes immediately after FIFA 11+ intervention in comparison to the control group (short-term effects). However, at long-term the changes in the hamstrings eccentric strength were significantly higher in the FIFA 11+ group.

The study by Impellizzeri et al. (Impellizzeri et al. 2013) which submitted a group of 42 football players to the FIFA 11+ program 3 times a week for 9 weeks (control group: 39 players) found significant differences in favour of the FIFA 11+ group, for hamstring concentric and eccentric strength, however the authors question the relevance of the improvements observed in their study (3–4%). Other FIFA 11+ related studies that tested strength showed significant gains in some of the parameters tested. For instance, the only futsal related study retrieved by Reis et al., showed significant gains after 12 weeks of intervention in 18 youth futsal players, in the concentric strength of quadriceps and hamstrings, in the eccentric muscle strength of the hamstrings as well as for the H/Q functional ratio (Reis et al. 2013). An earlier study by Brito et al., enrolling 20 football players to a 10-week FIFA 11+ program (3 times a week), revealed gains in isokinetic hamstring and quadriceps concentric strength, however, no changes were obtained for eccentric strength of the hamstrings (Brito et al. 2010). Other studies also showed gains in conventional strength ratio (Daneshjoo et al. 2012), hamstrings and quadriceps isometric strength (Abdolhamid Daneshjoo et al. 2013) and concentric hamstring strength (A Daneshjoo et al. 2013) in male professional soccer players. From a performance point of view, our long-term effects may not be meaningful, however, from an injury prevention perspective, they may be relevant as both eccentric hamstring strength and H/Q ratios are important factors related to hamstring injury (Dauty et al. 2016).

To our knowledge, no studies have tested the FIFA 11+ effects on muscle latency time after a sudden inversion of the ankle in futsal players, or in any other kind of population. Our study did not show gains in reduction of latency time after sudden inversion. Our results may be comparable to a study (Dias et al. 2011) that tested the effects of a 4-week balance training program on the latency of the ankle musculature in 34 healthy subjects with no history of ankle injury and showed no changes after intervention. The neuromuscular system provides the active or dynamic, restraint during a sudden inversion movement. As the peroneus muscles act as evertors against foot inversion (Linford et al. 2006), training of these muscles, to reduce the muscle reaction time, are of upmost importance for one of the most frequent time-loss injuries in football and futsal.

This study has some limitations. The testing of the participants were executed in post-work schedule, as all players were amateurs in which most had a day job. All the testing sessions accounted for the 48h period rest post-match, maintaining the same schedule as training days. Nevertheless, we did not control the work load, so the day of work's effort may have had an influence on the parameters assessed. Similarly, training methods and match playing time could have affected player's physical performance.

The H/Q functional ratio selected for this study was the eccentric peak torque of the hamstrings at 30º/s and the concentric peak torque of the quadriceps muscles at 240º/s). We selected this eccentric velocity due to the fact that the participants were amateur players, which were never submitted to isokinetic testing, nor specific eccentric training, as well due to the fact that this was the angular velocity by the only FIFA 11+ related futsal study retrieved. This velocity was chosen to establish familiarization with the eccentric exercise. However, we recognize that a higher velocity would have been a better choice for approximation to the actual speed that hamstring strains usually occur (Croisier et al. 2008).

Conclusion

The results obtained in our study showed no significant enhancements in strength and muscle latency time immediately after the FIFA 11+ intervention in comparison to the control group. However, at long-term some parameters, namely eccentric hamstrings strength, improved significantly.

Acknowledgments

We express our gratitude to Mr Norberto Rei for his helpful involvement during the experiment. We would also like to acknowledge the commitment and perseverance of all players, coaches and sports staff, and all technical supporting personnel, which made this study possible.

The European Regional Development Fund through the Operational Competitiveness Program, and the Portuguese Foundation for Science and Technology (FCT) support the research unit CIAFEL (REF: UID/DTP/00617/2013). iBiMED is a research unit supported by the Portuguese Foundation for Science and Technology (REF: UID/BIM/04501/2013) and POCI-01-0145-FEDER-007628 funds.

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Figures and Tables Legends

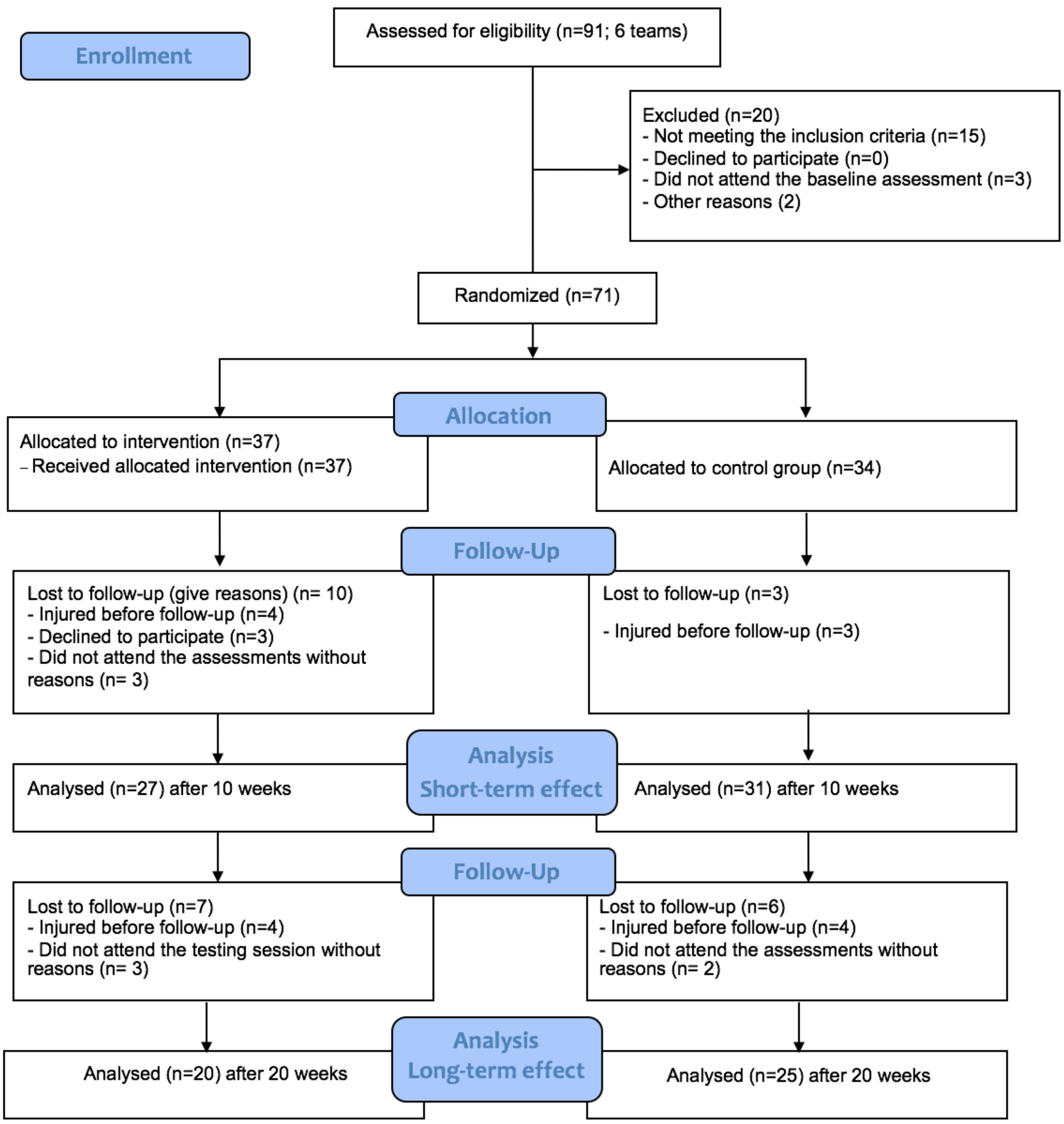

Figure 1. CONSORT participant's flow diagram.

Figure 2. Experimental setup for lateral ankle sprain simulating test.

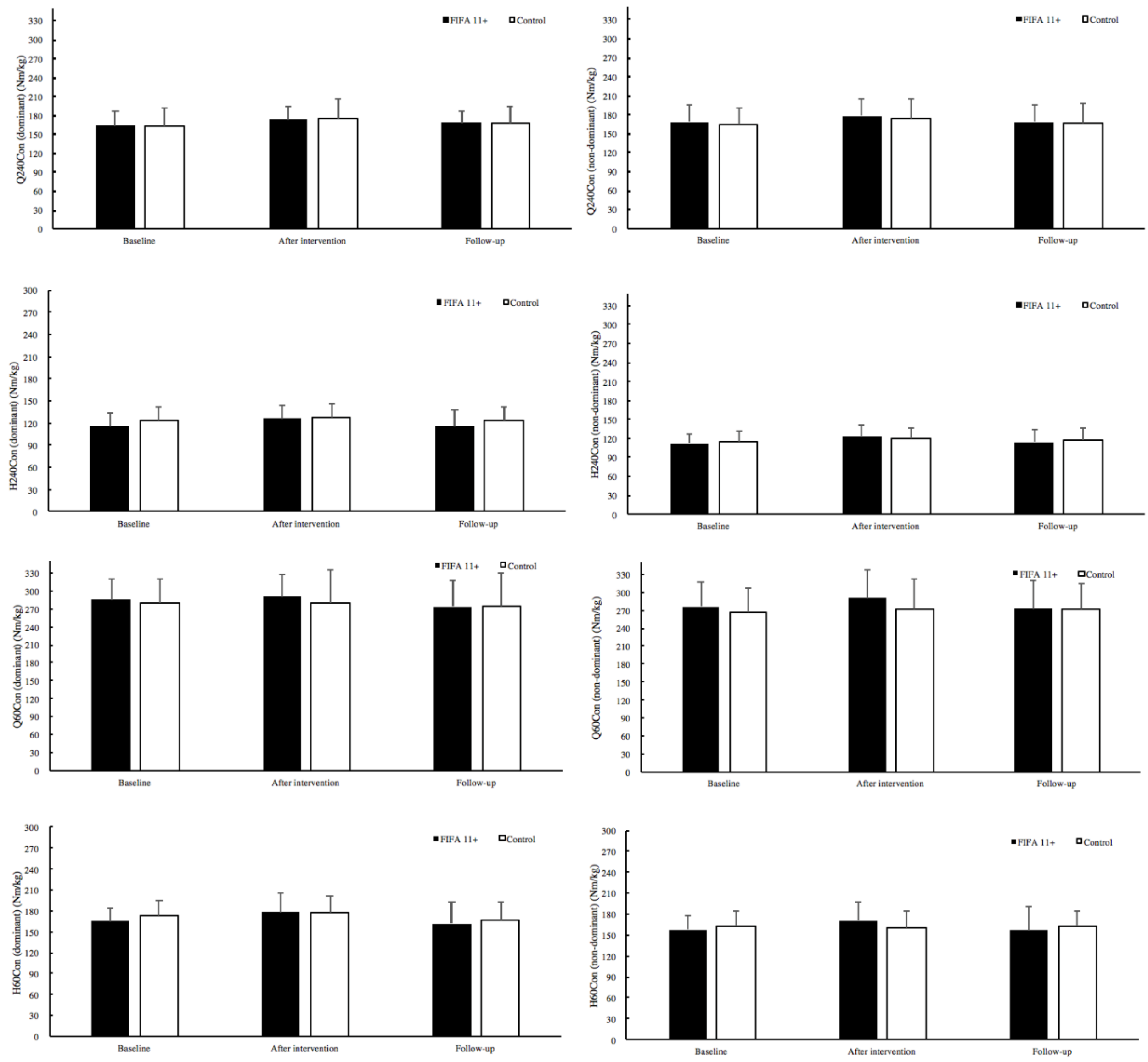

Figure 3. Isokinetic concentric strength at baseline, after intervention and at follow-up.

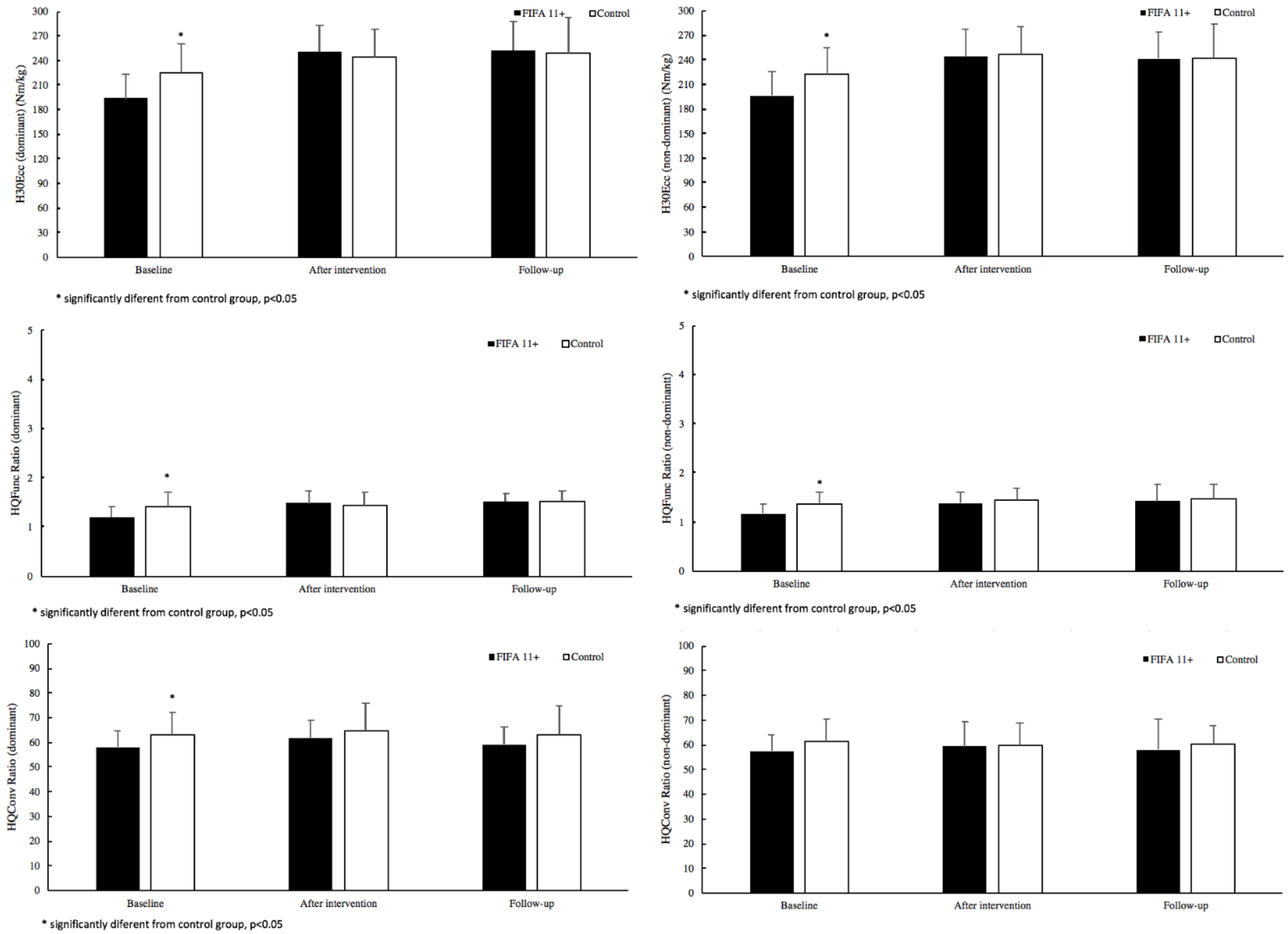

Figure 4. Isokinetic eccentric strength and H/Q ratios at baseline, after intervention and at follow-up.

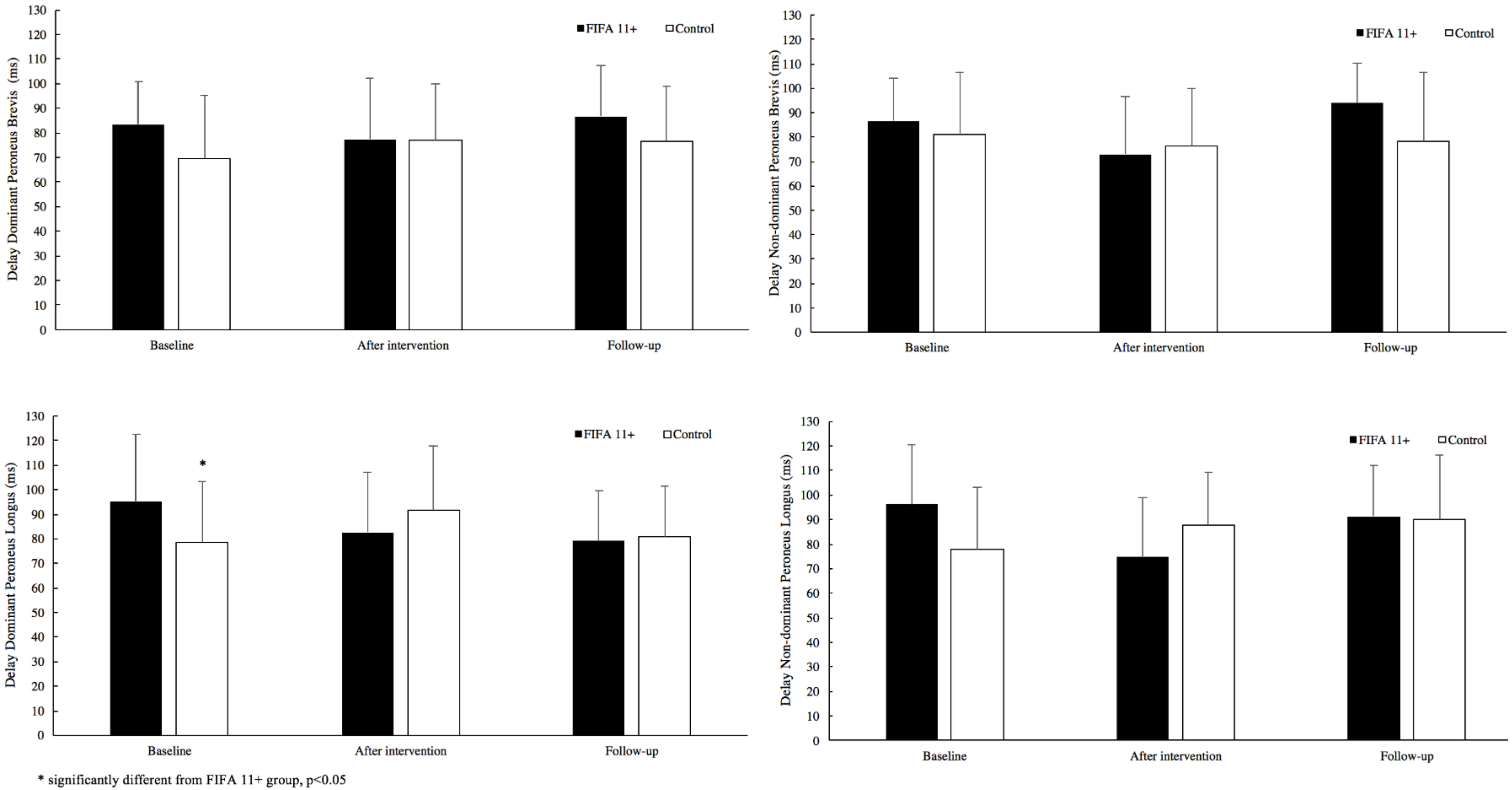

Figure 5. Evertor muscle latency time at baseline, after intervention and at follow-up.

Table 1. Baseline characteristics of the players stratified by group (mean ± SD).

	FIFA 11+	***Control***	***P value***
Age (years)	26.98 ± 5.11	26.03 ± 5.08	0.407
Weight (kg)	72.56 ± 9.33	78.79 ± 9.23	**0.005**
Height (cm)	174.50 ± 6.95	177 223 ± 6.48	0.083
Body Mass Index (kg/m^2)	23.79 ± 2.39	25.07 ± 2.47	**0.024**
Fat Mass (%)	15.67 ± 5.32	17.58 ± 5.24	0.125
Training exposure from T0-T1 (sessions/week)	2.60 ± 0.45	1.78 ± 0.47	**<0.001**
Training exposure from T0-T2 (sessions/week)	2.53 ± 0.46	1.81 ± 0.44	**<0.001**
Training exposure from T1-T2 (sessions/week)	2.43 ± 0.69	1.82 ± 0.54	**<0.001**

Table 2. Baseline measures for outcomes stratified by group (mean ± SD).

	FIFA 11+	*Control*	*P value*
Isokinetic strength			
Non-dominant Lower limb			
Quadriceps			
Concentric at 60º/s	276.67 ± 41.26	267.25 ± 39.79	0.380
Concentric at 240º/s	168.07 ± 26.01	164.26 ± 26.32	0.583
Hamstrings			
Concentric at 60º/s	157.72 ± 20.08	162.30 ± 21.04	0.402
Concentric at 240º/s	111.68 ± 16.04	114.18 ± 16.54	0.563
Eccentric at 30º/s	196.17 ± 29.68	222.90 ± 32.41	0.002
H/Q Conventional Ratio	57.55 ± 6.81	61.51 ± 8.67	0.061
H/Q Functional Ratio	1.18 ± 0.19	1.38 ± 0.23	0.001
Dominant Lower limb			
Quadriceps			
Concentric at 60º/s	285.88 ± 34.95	278.75 ± 42.11	0.490
Concentric at 240º/s	165.44 ± 19.16	173.87 ± 20.68	0.114
Hamstrings			
Concentric at 60º/s	163.25 ± 23.28	163.26 ± 28.92	0.999
Concentric at 240º/s	116.25 ± 17.98	124.43 ± 16.98	0.080
Eccentric at 30º/s	193.63 ± 29.50	227.52 ± 34.93	<0.001
H/Q Conventional Ratio	58.22 ± 6.27	63.22 ± 8.93	0.018
H/Q Functional Ratio	1.20 ± 0.21	1.42 ± 0.28	0.001
Latency time			
Non-dominant Lower limb			
Peroneus Brevis (ms)	88.23 ± 16.35	81.31 ± 25.05	0.207
Peroneus Longus (ms)	96.49 ± 19.98	78.37 ± 24.69	0.003
Dominant Lower limb			
Peroneus Brevis (ms)	79.26 ± 25.57	70.62 ± 18.35	0.151
Peroneus Longus (ms)	93.40 ± 29.13	79.27 ± 24.66	0.056

Table 3. Effects of FIFA 11+ and follow-up isokinetic tests (linear regression).

	Short-term effects				**Long-term effects**			
	Crude β (95% CI)		*Adjusted* β (95% CI)*		*Crude β (95% CI)*		*Adjusted* β (95% CI)*	
Quadriceps Con 60°/s								
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	9.21 (-7.99; 26.41)	3.49 (-16.44; 23.43)	3.46 (-26.27; 33.20)	-15.26 (-48.61; 18.09)	-2.77 (-20.05; 14.52)	-3.44 (-26.63; 19.74)	-23.83 (-51.75; 4.10)	**-41.02 (-79.53; -2.50)**
Control	0	0	0	0	0	0	0	0
Age	-	-	0.54 (-1.49; 2.55)	-1.68 (-3.94; 0.59)	-	-	-2.60 (-4.33; -0.87)	-3.16 (-5.54; -0.78)
Body Mass Index	-	-	1.58 (-2.25; 5.41)	0.90 (-3.40; 5.19)	-	-	2.73 (-0.61; 6.06)	-0.88 (-5.47; 3.72)
Training Exposure	-	-	8.31 (-16.58; 33.20)	25.32 (-2.59; 53.24)	-	-	33.67 (7.35; 59.99)	47.41 (11.12; 83.71)
Hamstrings Con 60°/s								
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	**13.32 (1.07; 25.57)**	9.19 (-2.45; 20.83)	10.01 (-11.53; 31.55)	7.47 (-12.76; 27.70)	3.50 (-9.71; 16.71)	4.66 (-7.55; 16.87)	2.14 (-20.66; 24.93)	0.26 (-21.91; 22.43)
Control	0	0	0	0	0	0	0	0
Age	-	-	-0.13 (-1.60; 1.33)	-0.22 (-1.60; 1.15)	-	-	-2.04 (-3.44; -0.63)	-1.36 (-2.73; 0.01)
Body Mass Index	-	-	-0.46 (-3.24; 2.31)	-1.32 (-3.92; 1.29)	-	-	-0.29 (-3.01; 2.43)	-0.31 (-2.96; 2.33)
Training Exposure	-	-	3.20 (-14.83; 21.23)	0.13 (-16.81; 17.06)	-	-	3.73 (-17.76; 25.20)	6.44 (-14.46; 27.33)
H/Q Conventional Ratio								
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	3.12 (-0.99; 7.23)	1.70 (-2.33; 5.72)	3.02 (-4.19; 10.23)	5.11 (-1.54; 11.76)	2.39 (-3.27; 8.05)	1.46 (-2.66; 5.57)	6.97 (-3.15; 17.09)	**9.38 (1.89; 16.86)**
Control	0	0	0	0	0	0	0	0
Age	-	-	-0.13 (-0.60; 0.34)	0.23 (-0.21; 0.68)	-	-	-0.19 (-0.79; 0.41)	0.23 (-0.23; 0.68)
Body Mass Index	-	-	-0.40 (-1.30; 0.50)	-0.46 (-1.32; 0.40)	-	-	-0.35 (-1.52; 0.81)	0.27 (-0.61; 1.15)
Training Exposure	-	-	-1.30 (-7.22; 4.62)	-5.94 (-11.40; -0.47)	-	-	-7.62 (-17.00; 1.76)	-9.36 (-16.29; -2.44)
Baseline Conventional Ratio	-	-	-0.21 (-0.49; 0.06)	-0.17 (-0.42; 0.09)	-	-	-0.33 (-0.67; 0.01)	-0.02 (-0.27; 0.23)
Quadriceps Con 240°/s								
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	-0.07 (-10.79; 10.65)	-1.23 (-11.65; 9.18)	-10.22 (-28.69; 8.24)	-8.79 (-26.66; 9.07)	1.98 (-11.49; 15.44)	-2.68 (-15.97; 10.60)	-6.96 (-31.62; 17.71)	**-29.04 (-51.63; -6.45)**
Control	0	0	0	0	0	0	0	0
Age	-		-0.30 (-1.56; 0.95)	-0.57 (-1.78; 0.65)	-	-	-1.21 (-2.74; 0.31)	-1.06 (-2.46; 0.34)
Body Mass Index	-		-0.80 (-3.18; 1.58)	0.42 (-1.88; 2.73)	-	-	0.98 (-1.96; 3.92)	-0.29 (-2.99; 2.41)
Training Exposure	-		10.67 (-4.78; 26.13)	10.14 (-4.81; 25.10)	-	-	14.09 (-9.15; 37.34)	32.37 (11.08; 53.66)
Hamstrings Con 240°/s								
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	6.11 (-2.04; 14.27)	6.73 (-0.86; 14.31)	2.56 (-11.44; 16.56)	-3.27 (-16.10; 9.56)	3.95 (-8.45; 16.34)	2.82 (-5.14; 10.78)	6.99 (-15.43; 29.41)	-3.07 (-17.81; 11.68)
Control	0	0	0	0	0	0	0	0
Age	-	-	-0.66 (-1.61; 0.29)	-0.22 (-1.09; 0.66)	-	-	-1.55 (-2.94; -0.16)	-0.60 (-1.52; 0.31)

Body Mass Index	-	-	-0.23 (-2.03; 1.57)	-0.58 (-2.23; 1.08)	-	-	1.06 (-1.61; 3.74)	-0.36 (-2.11; 1.40)
Training Exposure	-	-	4.66 (-7.06; 16.37)	10.73 (-0.01; 21.47)	-	-	0.35 (-20.78; 21.48)	7.17 (-6.73; 21.06)
				Hamstrings Ecc 30°/s				
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	**23.37 (7.12; 39.62)**	**39.86 (21.29; 58.43)**	3.95 (-23.20; 31.11)	-1.75 (-27.69; 24.19)	**33.42 (15.98; 50.86)**	**42.40 (22.69; 62.12)**	**38.24 (2.64; 73.84)**	**68.17 (30.65; 105.69)**
Control	0	0	0	0	0	0	0	0
Age	-	-	-0.24 (-1.98; 1.50)	-0.60 (-2.23; 1.03)	-	-	-1.54 (-3.52; 0.44)	-1.61 (-3.62; 0.40)
Body Mass Index	-	-	-3.60 (-7.23; 0.03)	-6.31 (-9.72; -2.90)	-	-	-0.27 (-4.45; 3.91)	-0.01 (-4.32; 4.29)
Training Exposure	-	-	0.16 (-21.13; 21.45)	4.91 (-15.03; 24.85)	-	-	-15.60 (-45.48; 14.27)	-44.88 (-75.22; -14.54)
Baseline Eccentric Peak Torque	-	-	-0.54 (-0.82; -0.26)	-0.85 (-1.10; -0.61)	-	-	-0.28 (-0.60; 0.03)	-0.33 (-0.65; -0.01)
				H/Q Functional Ratio				
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	**0.14 (0.03; 0.25)**	**0.25 (0.12; 0.37)**	0.13 (-0.07; 0.34)	0.15 (-0.07; 0.38)	0.16 (-0.02; 0.34)	**0.25 (0.07; 0.43)**	0.03 (-0.36; 0.42)	**0.51 (0.19; 0.83)**
Control	0	0	0	0	0	0	0	0
Age	-	-	0.01 (-0.01; 0.02)	0.01 (-0.01; 0.02)	-	-	0.00 (-0.02; 0.02)	0.00 (-0.01; 0.02)
Body Mass Index	-	-	0.01 (-0.02; 0.03)	-0.01 (-0.04; 0.01)	-	-	-0.01 (-0.05; 0.03)	0.01 (-0.02; 0.04)
Training Exposure	-	-	-0.08 (-0.23; 0.08)	-0.05 (-0.22; 0.12)	-	-	-0.03 (-0.35; 0.29)	-0.45 (-0.71; -0.19)
Baseline Functional Ratio	-	-	-0.37 (-0.63; -0.10)	-0.48 (-0.72; -0.24)	-	-	-0.60 (-1.06; -0.13)	-0.50 (-0.81; -0.19)

* Adjusted to all the variables presented in the table 1 and 2.

Table 4. Effects of FIFA 11+ and follow-up on evertor muscles latency time after sudden inversion testing (linear regression).

	Short-term effects				**Long-term effects**			
	Crude β (95% CI)		*Adjusted* β (95% CI)*		*Crude β (95% CI)*		*Adjusted* β (95% CI)*	
				Peroneus Brevis				
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	**-21.39 (-42.56; -0.22)**	-9.24 (-25.64; 7.17)	-0.14 (-43.64; 43.37)	-2.30 (-37.09; 32.48)	-3.30 (-26.09; 19.94)	10.83 (-6.89; 28.55)	-9.77 (-46.91; 27.36)	-1.18 (-30.23; 27.87)
Control	0	0	-	-	0	0	0	0
Age	-	-	-0.94 (-3.44; 1.57)	-1.25 (-3.21; 0.70)	-	-	-0.51 (-3.19; 2.17)	-0.07 (-2.09; 1.95)
Body Mass Index	-	-	0.93 (-3.87; 5.73)	2.74 (-0.94; 6.41)	-	-	-3.26 (-9.09; 2.57)	1.45 (-2.94; 5.84)
Training Exposure	-	-	-21.97 (-60.10; 16.15)	-4.57 (-34.77; 25.62)	-	-	4.01 (-32.12; 40.14)	17.24 (-10.82; 45.30)
				Peroneus Longus				
	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant
Group								
FIFA 11+	-38.79 (-59.71; -17.87)	**-22.38 (-44.24; -0.53)**	6.84 (-23.26; 36.94)	-19.64 (-55.26; 15.97)	-24.51 (-47.66; -1.37)	1.54 (-19.44; 22.53)	-5.60 (-32.75; 21.55)	-3.83 (-24.63; 16.97)
Control	0	0	-	-	0	0	0	0
Age	-	-	-0.13 (-1.87; 1.60)	-0.19 (-2.21; 1.82)	-	-	-0.25 (-2.21; 1.71)	0.79 (-1.37; 1.53)
Body Mass Index	-	-	0.76 (-2.50; 4.02)	1.63 (-2.14; 5.40)	-	-	-1.74 (-5.99; 2.52)	-2.02 (-5.15; 1.11)
Training Exposure	-	-	-27.94 (-54.64; -1.24)	12.83 (-18.17; 43.84)	-	-	-8.90 (-36.12; 18.31)	16.62 (-3.84; 37.09)
Peroneus Longus Delay (on-dominant)			-0.90 (-1.21; -0.60)	-	-		-0.78 (-1.13; -0.43)	
Peroneus Longus Delay (dominant)	-	-		-0.83 (-1.17; -0.49)	-	-		-0.86 (-1.10; -0.63)

* Adjusted to all the variables presented in the table 1 and 2.

STUDY IV

Effects of the FIFA 11+ on injury prevention in amateur futsal players.

Lopes, M., Costa, R., Oliveira, J., Ribeiro, F.

Submitted.

Effects of the FIFA 11+ on injury prevention in amateur futsal players.

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Acknowledgments

The European Regional Development Fund through the Operational Competitiveness Program, and the Portuguese Foundation for Science and Technology (FCT) support the research unit CIAFEL (REF: UID/DTP/00617/2013). iBiMED is a research unit supported by the Portuguese Foundation for Science and Technology (REF: UID/BIM/04501/2013) and POCI-01-0145-FEDER-007628 funds.

ABSTRACT

BACKGROUND: The FIFA 11+ has shown to be effective regarding the reduction of injury risk in football players. Yet no study has been conducted in futsal players. The purpose of this study was to examine the effectiveness of the FIFA 11+ in reducing injury in amateur futsal players.

METHODS: Seventy-one male futsal players from six amateur futsal clubs were recruited and randomized to two groups: an experimental group, (FIFA 11+ group; n=37, age: 27.0±5.1 years) and a control group (Regular warm-up group; n=34, age: 26.0±5.1 years). The FIFA 11+ program was executed twice a week, for 20 weeks, separated by a 10-week period where both groups executed their regular warm-up. Data on match, training exposure and injuries were recorded during the regular season.

RESULTS: The 65 players included in the study, sustained a total of 58 injuries, during the futsal regular season, of which, 24 in the intervention group (31 players) and 24 in the control group (34 players). The overall incidence of injuries for the control group was 11.6 (CI 8.1 ; 15.0) per 1000 player hours 129.2 (CI 52.4 ; 206.2) in matches and 6.2 (CI 3.0 ; 9.5) in training. The FIFA 11+ presented a lower overall incidence of injuries 6.5 (CI 4.5 ; 8.5) per 1000 player hours 85.5 (CI 43.6 ; 127.3) in matches and 2.3 (CI 0.8 ; 3.7) in training. Players from the control group presented a higher number of days injured (p=0.036).

CONCLUSION: The results obtained in our study, showed a significant reduction of overall, acute injuries, lower limb injuries as for injuries during training sessions. We may conclude that the FIFA 11+ is an injury prevention program suited for injury reduction in amateur futsal players.

KEY WORDS: warm-up, injury severity, time-loss injuries, adults.

Introduction

Futsal has registered in recent years a fast but steady growth around the world, although it has been around since the 1930´s (Junge & Dvorak 2010; Berdejo-del-fresno 2014; FIFA 2015). Futsal may be similar to football, however it possesses its own specificities. The smaller size of the pitch, the reduced number of players (5 on each side), specific rules and tactical actions, make futsal a physically demanding sport (FIFA 2015; Moore et al. 2014; Barbero-Alvarez et al. 2008).

The fast growth in the rates of futsal participation is increasing the awareness and concern regarding the public health significance of futsal injuries, as it was estimated that the rate of injuries in futsal is the double of football (Junge & Dvorak 2010). The ankle, groin and thigh strains are the most prevalent diagnoses when it comes to time-loss injuries in futsal (Ribeiro et al. 2006; Junge & Dvorak 2010). Previous studies commonly indicate the ankle sprain as one of the most prevalent time-loss injuries in futsal (Junge & Dvorak 2010), representing 48.8% of all injuries (Serrano et al. 2013). The injuries with contact seem to be predominant, however the major part of the injuries do not represent time-loss injuries (Ribeiro et al. 2006).

As in football, it is of interest to reduce injury risk of futsal players (Matos et al. 2008). Indeed, there is need for better understanding on the incidence, characteristics and causes of futsal injuries at all playing levels so that specific programs to prevent injuries may be developed for this sport (Junge & Dvorak 2010). From a practical point of view, it is difficult to find a standard of care for evidence-based injury-prevention strategies in amateur futsal players. In the last decade, the FIFA 11+, an injury prevention program that does not require specific equipment for execution (Bizzini et al. 2011), has emerged as an effective strategy to reduce injury incidence in amateur football players. No study was conducted so far to examine the effectiveness of the FIFA 11+ program in reducing injury in futsal players, but based on data from previous FIFA 11+ studies in football players, we hypothesize that this program would also reduce the number of injuries as well as their severity in futsal players. Therefore, this study aimed to analyse effects of the FIFA 11+ on injury prevention in futsal players.

Methods

Study design and randomisation procedures

This study, was a parallel, two-group, stratified randomised controlled trial. Randomization and allocation (allocation ratio 1:1) of the teams that were fully eligible was assured by a blinded assistant, without any affiliation or acknowledgement of the teams, to the control and experimental groups by selection of one of two sealed, opaque, envelopes containing the group allocation. Study details are presented according to the CONSORT statement (Schulz et al. 2010).

The international consensus guidelines for injury surveillance in football was used as part of the study for data collection, procedures and terminology (Fuller et al. 2006). The variables collected included players baseline information as player's position, age, stature, body mass and dominant leg, as well as, match and training time exposure, weekly training exposure, FIFA 11+ exposure and injury data during the regular season (2014/2015) (Figure1. Flow diagram).

Written informed consent was obtained from all players and all procedures were conducted according to the Declaration of Helsinki. The study was approved by the ethical committee of the Faculty of Sport, University of Porto.

Participants

All 34 amateur senior male futsal teams competing in the Football Associations of Coimbra and Aveiro, Portugal, were contacted to participate in the study by e-mail. The details of the study were explained by the researcher to the managers and players of the clubs to the 24 teams that expressed interest to participate in the study. A period of 4 weeks was assumed to acquire full consent of the club (including players, managers and directors consent). Following this period, 14 teams confirmed interest to participate in the study. Randomly 6 teams were selected and randomly allocated by a blinded assistant into two groups: control (3 teams) and FIFA 11+ (3 teams).

Consequently, the players of each team were submitted to eligibility criteria. Inclusion criteria: 1) male amateur futsal players competing in the Official Regional Amateur Futsal Championships of the Districts of Aveiro (1^{st} and 2^{nd} division) and Coimbra (unique division) of the Portuguese Football Federation, 2) players aged $\geq$ 18 years, 3) players which did not have interaction with the “FIFA 11+” in previous years, 4) attendance to a minimum of 2 training sessions per week along with match (which excluded players with less training sessions due to career compromises which can be common in amateur teams). The exclusion criteria were: 1) severe injury within 6 weeks of the initiation of the study; 2) players that experienced health issues (e.g. cancer, arthritis, heart disease, pulmonary disease, neurological disease) which prevented full participation at the beginning of the season. Furthermore, players who switched club during the research or those in the intervention group who did not attend at least 80 % of the “FIFA 11+” sessions were excluded from the analysis.

Interventions

The intervention lasted 20 weeks (5 months) and was delivered in two periods of 10 weeks separated by a 10-week period in-between. The coach, supported by one or two players of the team (normally the captain and sub-captain), were selected to guarantee the delivery of "FIFA 11+". The formation of the intervention delivery agents was guaranteed by the researcher. The coach was selected as the key element to administer the program to reassure a greater rate of compliance of the players towards the program (Soligard et al. 2010; Bizzini et al. 2011). The players in the 3 intervention teams had access to paper and video support regarding the FIFA 11+ program. The 3 teams started in first level and evolved to the next level in three weeks, meaning that all teams had 4 weeks of FIFA 11+ in the third level. The second 10-week period (reloading) of the program followed the same protocol. Considering that the teams were amateur, expecting a small weekly training frequency, it was defined to execute the FIFA11+, twice a week, as it is the recommended minimum to retrieve the proclaimed effects of the program (Bizzini et al. 2011). The average duration of the FIFA 11+ intervention of 20 minutes matched the average time of regular warm-ups of the control group. The warm-ups of the teams in the control group included a combination of running, ball and dynamic stretching exercises succeeded in progressive order of speed and intensity. All teams were visited on a regular basis by the researcher and an assistant to insure the correct delivery of the program.

Outcome measures

Player's baseline characteristics

The baseline information collected included, player´s position, age, stature, weight, dominant leg and details of previous major injuries. Body weight was obtained with the body composition analyser (Seca mBCA 515, Seca, Birmingham, UK), the height of the players with the digital stationary stadiometer (Seca 264, Seca, Birmingham, UK), and body mass index (kg/m^2) was calculated.

Exposure and injury registration

The recording of match and training exposure as well as injury data was guaranteed on a daily basis on registration forms by a selected team responsible, as not all teams had the same supporting staff. The reports were either filled out by the coach (1 team), physiotherapist (2 teams), assistant coach (1 team) and team's captain/sub-captain (2 teams). Specific injury data of the teams that did not have a physiotherapist permanently present were assured by other external physiotherapists.

All injuries were categorized according to type, location, body side, mechanism of injury (traumatic or overuse), whether the injury was a recurrence onset, severity and if it was during training or match. An injury was defined as any physical complaint sustained by a player that results from a match or training, irrespective of the need for medical attention or time-loss from sports practice; and, a time-loss injury as injuries that inhibits the player to take full part in forthcoming training or match play (Fuller et al. 2006). Injury severity was categorized based on the number of days from the date of injury to full return to team training or matches (Fuller et al. 2006). Classification was set in accordance to the consensus agreement of injury definitions: slight (0 days); minimal (1–3 days); mild (4–7 days); moderate (8–28 days); severe (>28 days); career ending (Fuller et al. 2006).

Data Analysis

All analyses were conducted on SPSS version 24.0 (SPSS Inc., Chicago, IL, USA). Normality of data distribution was tested with the Shapiro-Wilk test. Descriptive statistics were used to calculate the mean and standard deviation (SD). Injury incidence rates (number of injuries/1000 player-hours) were calculated for each of the two randomised groups. The independent T-test and chi-square were used to compare variables between groups. The significance level was set at $p < 0.05$ and all tests were two-tailed.

Results

Of the total of 71 players which participated in the study, 37 were allocated to the intervention group and 34 to the control group. After baseline assessments, 6 players from the experimental group dropped out. The flow diagram is displayed in Figure 1.

Baseline characteristics of players are presented in table 1. The control group had higher body weight ($p=0.005$) and body mass index ($p=0.024$), and a lower number of training sessions per week ($p<0.001$). The weekly average of FIFA 11+ exposure was 1.78 ± 0.28 sessions.

Futsal exposure and injury characteristics

The players in the intervention group played 3977 hours of futsal (3768 training and 209 match hours) and those in the control group 3303 hours (3081 training and 222 match hours). Considering that match time was similar (FIFA 11+: 209; Control: 222 h), training was significantly different (weekly training exposure: FIFA 11+: 2.58 ± 0.35; control: 1.84 ± 0.41 days; $p<0.001$). The 65 players included in the study, sustained a total of 58 injuries, during the futsal regular season, of which, 24 in the intervention group (31 players) and 24 in the control group (34 players). Of the 58 injuries, 54 (93.1%) were acute injuries, 42 (72.4%) were in the lower limb, in which 13 (22.4%) were in the ankle. The most frequent type of injury was “haematoma/contusion/bruise” with 29 (50%) of all injuries, followed by “sprain/ligament injury” with 13 (22.4%). More than half the injuries were due to contact with other players 35 (60.3%) (Table 2).

Effect of the FIFA 11+

The control group presented a higher rate of total number of injuries (p= 0.014), acute injuries (p=0.007), lower limb injuries (p=0.032) and training injuries (p=0.028) per 1000 player hours. Also the time-loss injuries per 1000 player hours were almost significantly greater for the control group almost reaching significance (p=0.051) (Table 2). Players from the control group presented a higher number of days injured (p=0.036). These players also showed a higher (%) of sprain/ligament injuries (p=0.045) and also presented a higher (%) of moderate injury severity (p=0.025) when comparing to the FIFA 11+ group (Table 3).

Discussion

The purpose of this study was to evaluate the effect of the FIFA 11+ program on injury prevention, amongst amateur futsal players. Our main results indicate a significant reduction in injuries overall, acute injuries, lower limb injuries and in training injuries.

Our results in futsal amateur players are in line with those showing that the FIFA 11+ significantly reduces injuries in football players (Soligard et al. 2008; Steffen et al. 2013; Grooms et al. 2013; Bollars et al. 2014; Owoeye et al. 2014; Silvers-Granelli et al. 2015) as well as in elite male basketball players (Longo et al. 2012). However, not all studies demonstrated injury reduction with the FIFA 11+. Hammes et al. did not reach the desired injury prevention effects in their study, however the FIFA 11+ sessions did not achieve the minimum recommendation of two weekly sessions to obtain the proclaimed effects (Hammes et al. 2015). As we did not find a study that assessed injuries as outcome in futsal athletes, this may be the first study that has accomplished results for injuries as outcomes .

The key elements in the FIFA 11+ injury prevention program are considered essential requirements for injury prevention. They are core strength, neuromuscular control and balance, eccentric hamstrings training, plyometrics and agility (Bizzini et al. 2011). Others refer alterations in neuromuscular control of the trunk may be an underlying factor justifying the protective effect of the FIFA11+. Still, mechanisms underlying this protective effect of injury prevention programs are still poorly understood (Whittaker & Emery 2015).

Regarding the incidence of injuries, our study shares similar results to studies that investigated injuries in futsal. For instance, Dvorak and Junge (Junge & Dvorak 2010) refer that 70% of injuries affect the lower extremity. Our study, revealed that 42 out of 58 injuries registered were of the lower limb, which implied 72.4% of all injuries. In the study by Varkiani (Varkiani et al. 2013), the injuries of the lower limb reached 64% of all injuries, while in other study lower limb injuries corresponded to 82% of all injuries (Peterson et al. 2000). A study (Ribeiro et al. 2006) registering the injuries during the 15th Brazilian Indoor Soccer (Futsal) Sub20 Team Selection Championship also presented some similarities to our study; they observed that most injuries (65.62%) were contact injuries which may be comparable to our global data of 70.6% of total injuries were made by contacting another player, the ball or another object.

The study by Serrano et al (Serrano et al. 2013) which also studied futsal injuries, revealed data that is in accordance with our study, where a greater rate of injuries are due to collision with other players (55.3%), as supported by other studies (Ribeiro et al. 2006; Junge & Dvorak 2010). However, the majority of the futsal related studies referred (Ribeiro et al. 2006; Junge & Dvorak 2010), registered a higher number of injuries without time-loss compared to our results (29.3%). This may mean that the lack of consistent medical assistance during training sessions and matches, of the majority of the clubs that participated in the study which may have led to a lower rate of registration of minor injuries.

We acknowledge some limitations. As the coach or an assistant designated in the beginning of the study, of each team recorded the match and training exposure, as well as compliance with the FIFA 11+, we may assume that over- or under- reporting could have occurred. Due to the fact that not all of the participating teams in our study, had a physiotherapist or other clinical qualified personnel, in the field during matches and training sessions, we incurred a risk of leaving out less relevant injuries. Nonetheless, to reduce the risk of bias, the researcher and an assistant, visited each team at least once a week during the experimental period.

Conclusion

The results obtained in our study, showed a significant reduction of overall, acute injuries, lower limb injuries as for injuries during training sessions. We may conclude that the FIFA 11+ is an injury prevention program suited for injury reduction in amateur futsal players.

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Figure and Table Legends

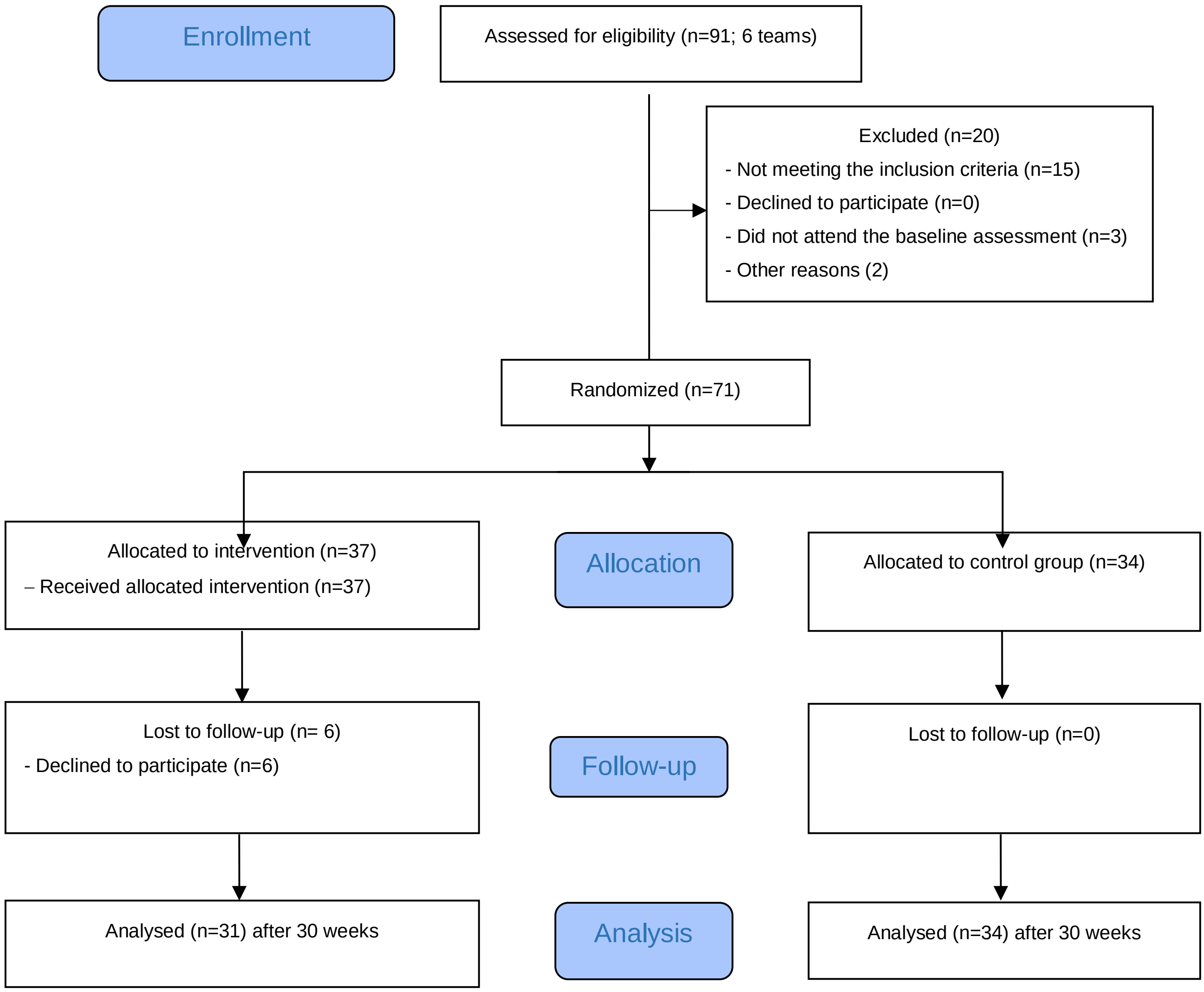

Figure 1. CONSORT participant's flow diagram.

Table 1. Baseline characteristics of the players stratified by group (mean ± SD).

	FIFA 11+	*Control*	*P value*
Age (years)	27.71 ± 5.04	25.79 ± 4.92	0.126
Weight (kg)	72.77 ± 8.94	78.99 ± 9.29	**0.008**
Height (cm)	173.94 ± 6.57	177.32 ± 6.56	0.072
Body Mass Index (kg/m^2)	24.01 ± 2.87	25.11 ± 2.50	**0.044**
Fat Mass (%)	15.65 ± 5.23	17.56 ± 5.33	0.155
Training exposure (sessions/week)	2.58 ± 0.35	1.84 ± 0.41	**<0.001**
Average number of matches (per player)	23.1 ± 4.4	21.4 ± 6.4	0.234
Average match time exposure (hours)	6.7 ± 2.8	6.5 ± 4.0	0.831

Table 2. Injury incidence rates in amateur futsal players.

Group Injuries	Number of players	Number of player hours	Number of injuries	Injury Rate (number of injuries/1000 player-hours)	Mean difference (95% IC)	P value
All injuries						
Control	34	3081	34	11.6 (8.1 – 15.0)	-5.1 (-9.1 to -1.1)	**0.014**
FIFA 11+	31	3768	24	6.5 (4.5 – 8.5)		
Acute injuries						
Control	34	3081	33	11.2 (7.6 – 14.7)	-5.5 (-9.4 to -1.6)	**0.007**
FIFA 11+	31	3768	21	11.2 (7.6 – 14.7)		
Chronic injuries						
Control	34	3081	1	0.4 (-0.4 – 1.2)	0.5 (-0.8 to 1.8)	0.451
FIFA 11+	31	3768	3	0.8 (-0.1 – 1.9)		
Lower-limb injuries						
Control	34	3081	27	8.7 (5.3 – 12.0)	-4.2 (-8.1 to-0.4)	**0.032**
FIFA 11+	31	3768	15	4.4 (2.4 – 6.4)		
Ankle sprain						
Control	34	3081	9	3.7 (0.8 – 6.5)	-2.8 (-5.8 to 0.2)	0.065
FIFA 11+	31	3768	3	0.8 (-0.1 – 1.8)		
Time-loss injuries						
Control	34	3081	24	8.6 (5.2 – 12.0)	-3.9 (-7.8 to 0.02)	0.051
FIFA 11+	31	3768	17	4.7 (2.7 – 6.7)		
Match injuries						
Control	34	222	17	129.2 (52.4 – 206.2)	-43.8 (-130.1 to 42.5)	0.313
FIFA 11+	31	209	16	85.5 (43.6 – 127.3)		
Training injuries						
Control	34	2859	17	6.2 (3.0 – 9.5)	-4.0 (-7.5 to -0.5)	**0.028**
FIFA 11+	31	3559	8	2.3 (0.8 – 3.7)		

Table 3. Player exposure and injury characteristics.

	FIFA	**Control**	**P value**
Total days injured	10.5 ± 9.1	20.4 ± 17.3	**0.036**
Injury severity			
Slight (0 days)	6 of 24 (25.0%)	10 of 34 (29.4%)	0.258
Minimal (1-3 days)	6 of 24 (25%)	7 of 34 (20.6%)	0.575
Mild (4-7 days)	6 of 24 (25.0%)	2 of 34 (5.9%)	0.101
Moderate (8-28 days)	5 of 24 (20.8%)	14 of 34 (41.2%)	**0.025**
Severe (>28 days)	1 of 24 (4.2%)	1 of 34 (2.9%)	0.730
Injured body part			
Low back/sacrum/pelvis	2 (8.3%)	1 (2.9%)	0.465
Shoulder/clavicular	2 (8.3%)	2 (5.9%)	0.658
Wrist	0 (0%)	3 (8.8%)	0.137
Hand/finger/thumb	3 (12.5%)	1 (2.9%)	0.271
Hip/groin	2 (8.3%)	1 (2.9%)	0.730
Thigh	3 (12.5%)	6 (17.6%)	0.287
Knee	4 (16.7%)	6 (17.6%)	0.428
Lower leg/Achilles tendon	1 (4.2%)	2 (5.9%)	0.535
Ankle	4 (16.7%)	9 (26.5%)	0.146
Foot/toe	3 (12.5%)	3 (8.8%)	0.618
Type of injury			
Sprain/ligament injury	3 (12.5%)	10 (29.4%)	**0.045**
Lesion of meniscus or cartilage	1 (4.2%)	1 (2.9%)	0.730
Muscle rupture/strain/tear/cramps	3 (12.5%)	6 (17.6%)	0.287
Tendon injury/rupture/tendinosis/bursitis	1 (4.2%)	0 (0%)	0.477
Haematoma/contusion/bruise	14 (58.3%)	15 (44.1%)	0.565
Other injury	2 (8.3%)	2 (5.8%)	0.658
Injury recurrence	6 (25.0%)	12 (35.3%)	0.123
Injury contact/collision			
No	6 (25.0%)	11 (32.4%)	0.182
Yes, with another player	15 (62.5%)	20 (58.8%)	0.276
Yes, with the ball	2 (8.3%)	3 (8.8%)	0.545
Yes, with other object	1 (4.2%)	0 (0%)	0.477

CHAPTER 3

DISCUSSION

DISCUSSION OF METHODOLOGY

Literature is clear in supporting the use of injury preventive programs for injury reduction in sports practice (Herman et al. 2012; Bollars et al. 2014; Barengo et al. 2014; Emery et al. 2015; Gomes Neto et al. 2016; Thorborg et al. 2017). As football is the most practiced sports in the world, it is clear that it may be also be the most studied sport regarding injury prevention. Unfortunately, the existing evidence for the effectiveness of exercise-based programs to prevent football injuries is not all consensual (Van Beijsterveldt et al. 2013; Fernandes et al. 2015). As the current evidence may not be consensual, the extent to which the existent results that may be effectively adapted to futsal may also be, to some extent, uncertain. To our knowledge, only one futsal related FIFA 11+ study has been published (Reis et al. 2013). In this study, the authors aimed to study the physical fitness and technical performance of youth futsal players. As it may be of interest to continue to research in this fast growing sport, we further investigated the impact of the “11+” in senior amateur futsal players.

Based on the study by Reis et al. we decided to analyse some performance parameters included in their study along with others that may be of interest to the FIFA 11+ program and to futsal (Reis et al. 2013). The outcomes selected by Reis et al. included isokinetic testing, comprising concentric quadriceps (Q) and hamstrings (H) peak torque analysis at 60º/s and 240º/s and eccentric peak torque analysis of the hamstrings at 30º/s. In the jump performance testing, we only selected the squat jump, and the speed and agility performances were tested with the 30-meter sprint test, and the T-Test, respectively. Balance performance was tested not by the single-legged flamingo balance test, but with the single legged balance test on the force platform (gold standard). Accordingly, static balance may be assessed by postural sway on the force platform, as seen in other sport related studies (Paillard & Noé 2006; Agostini et al. 2013; Pau et al. 2014). For timewise reasons, we chose not to test for technical skill and selected other neuromuscular outcomes as dynamic balance, proprioception, muscle reaction time, as well as flexibility.

We considered important to assess flexibility, as flexibility seems to be higher in futsal players than in athletes of other sports activities as football, tennis, handball and in long-distance running (Cejudo et al. 2014). Another reason settled on the fact that two FIFA 11+ related studies analysed flexibility in amateur football players (Ayala, Calderón-López, et al. 2017; Ayala, Pomares-Noguera, et al. 2017), the first tested the acute effects of the "11+" and the second analysed the intervention after 4 weeks. No enhancements were observed in the flexibility parameters tested in both studies. This fitness component, is considered important for futsal performance and for injury prevention in this sport (Cejudo et al. 2014). We do however recognize that this fitness component is not consensual regarding injury prevention in other sports as football (Doormaal et al. 2017).

The "11+", calls the attention of the factors known to be important in the prevention of knee and ankle injuries. For instance, agility drills and plyometrics are considered important components of the program, as they have proved to be effective, not only in the prevention of ACL injuries, but in other knee and ankle injuries as well. Therefore, the athlete has to be fully aware and focused on his body control, to fulfil the program with proper execution techniques, and maintaining a good posture with correct body alignment in all moments (Bizzini et al. 2011; F-MARC 2015). The requirement to maintain appropriate posture, and correct body alignment requires a complex interaction of muscle activity of the trunk and lower limb, coordinated by the central nervous system (Guskiewicz & Perrin 1996; Ellenbecker et al. 2012). For futsal and for football, while protecting or dominating the ball from the opponents as well as for kicking, the player needs good single-leg balance (Cain et al. 2007; Matsuda et al. 2010). In fact, literature refers that football training enhances single leg stance (Matsuda et al. 2010; Teixeira et al. 2011). However, as important as static balance may be, its assessment gives limited information considering the athletes' degree of functionality. Dynamic balance testing may complement the necessary needs to fully assess balance of the athlete, as it is considered a constituent of an athlete's level of neuromuscular control (Gribble 2003). Dynamic balance has been object of consideration in other FIFA 11+ related studies (Daneshjoo et al. 2012b; Steffen et al. 2013; Bizzini, Impellizzeri, et al. 2013; Impellizzeri et al. 2013; Ayala, Calderón-López, et al. 2017; Ayala, Pomares-Noguera, et al. 2017), so it was also selected to be tested in our study.

As referred in FIFA´s 11+ manual, balance and neuromuscular control are part of the key elements in FIFA´s injury prevention program (Bizzini et al. 2011). Proprioception, muscle strength, muscle reaction time, and postural control are components of neuromuscular control (Richie D.H. 2001). In fact, proprioception has been object of consideration in literature in multiple ways (Ribeiro et al. 2007; Ribeiro et al. 2011), as synonymous for neuromuscular training protocols, considered proprioceptive training (Hübscher et al. 2010), as in the analysis of proprioceptive parameters in specific conditions like, experimentally-induced fatigue or match / practice-induced fatigue (Ribeiro et al. 2008; Gear 2011; Salgado et al. 2015), after warm-up (Magalhães et al. 2010), after cryotherapy (Oliveira et al. 2010; Ribeiro et al. 2013), in patellar tendinopathy of athletes (Torres et al. 2017) as well as in the analysis of proprioception in injury prevention context (Subasi et al. 2008; Mota & Ribeiro 2012; Leite et al. 2012; Venâncio et al. 2016). Proprioception is commonly tested by the assessment of the sub modalities of sense of tension (resistance), sense of movement (kinesthesia) and joint position sense. The sense of resistance is the ability to acknowledge and distinguish the force generated (Ellenbecker et al. 2012). Kinesthesia is evaluated by determining the threshold to detection of passive motion (Lephart et al. 1998). Joint position sense requires the subject to acknowledge the orientation of an extremity / joint in space (Lephart et al. 1998; Ellenbecker et al. 2012). We selected joint position sense as it a measure widely used in sports, and due to the fact that the only FIFA 11+ related study retrieved that assessed proprioception also used joint position sense (Daneshjoo et al. 2012a). However, Daneshjoo et al. used the Biodex Isokinetic Dynamometer (Biodex 3, 20 Ramsay Rode, Shirley, New York) to assess passive joint position sense at 30, 45 e 60º of knee flexion, when we selected active joint position sense, so it could be possible to conduct in the team´s own sports hall, reducing as well the assessment time, as it is a quicker method compared to the method used with the isokinetic dynamometer.

Proprioception is a vital component, associated to vestibular and visual input, to postural control, balance, postural and joint stability (Ergen & Ulkar 2008). Improvement of functional joint stability by neuromuscular (or proprioceptive) training is as crucial for rehabilitation as for prevention of athletic injuries (Ergen & Ulkar 2008; Ellenbecker et al. 2012). A simple measure to assess dynamic stability of the joints is the assessment of muscle reaction time of the muscles that protect the joint against a potential injury mechanism. In fact, the measurements of peroneal reaction time by surface electromyography (sEMG) has proven to be a reliable method to evaluate the dynamic stability of the ankle joint (Benesch et al. 2000) which is one of the most frequent injuries in football (Junge & Dvorak 2004; Wong & Hong 2005; Ergen & Ulkar 2008) as in futsal (Junge & Dvorak 2010; Serrano et al. 2013; Varkiani et al. 2013). The sudden ankle inversion test permits the analysis of peroneal muscle reaction time, which may be defined as the time lapse between the beginning of the inversion movement and the first muscular motor response, determined using sEMG (Menacho et al. 2010). In the systematic review by Menacho et al., neuromuscular control deficits were found between injured and uninjured ankles, which were demonstrated by significant differences in peroneus longus reaction times. The authors demonstrated that subjects with ankle injury present greater reaction time delays (when compared with limbs from different asymptomatic subjects) and claimed that these differences should be considered in assessment of the subject as well as an outcome in rehabilitation programs (Menacho et al. 2010). Regarding injury prevention interventions, muscle reaction time has been used for testing in a diversity of studies (Sheth et al. 1997; Linford et al. 2006;

Han & Ricard 2011; Dias et al. 2011; Yoshida et al. 2013). When it comes to the analyses of literature referring muscle reaction time regarding the FIFA 11+, to our best knowledge, no study was found. Since the ankle sprain is one of the most prevailing injuries in futsal, and as the FIFA 11+ has shown injury prevention effects, it is of interest to assess the effects of the program in the reaction time of the muscles that protect the ankle in injury mechanism of inversion of the ankle.

Discussion of main results

The main outcomes of the research studies that compounded this thesis, revealed that the FIFA 11+ did not exert statistical significant changes on the tests selected to assess performance and neuromuscular function on the participating amateur senior futsal players. However, the participants in the experimental group did reveal a significant reduction in overall injuries, as well as in time-loss injuries, demonstrating a lower absenteeism in sports participation due to injury.

The FIFA 11+ is probably the most disseminated injury prevention program in the world, due to the fact that it is recommended for amateur football by the world regulating body for football, due to the facility of application in any kind of setting, but also, clearly, due to its effectiveness in injury reduction.

To our knowledge, our study entitled, *Effects of the FIFA 11+ on injury prevention in amateur futsal players*, is the first study that analysed injuries in futsal players submitted to the FIFA 11+. The results obtained are in accordance to other studies that analysed the effect of the program on football players. Literature accounts for a few systematic reviews that are consensual about the effectiveness of the FIFA 11+ in injury reduction (Barengo et al. 2014; Al Attar et al. 2016; Thorborg et al. 2017; Sadigursky et al. 2017).

The systematic review and meta-analysis by Al Attar et al. analysed RCTs and interventional studies that assessed F-MARC injury prevention programs, “The 11” and the “11+”. The researchers concluded that only the FIFA 11+ decreased the risk of injuries amongst football players. This preventive effect could possibly be due to the fact that the “11+” presented supplementary exercises, and increased intensity compared to its predecessor. The constant call of attention to the correct execution of the exercise drills, as well as correction of body posture and neuromuscular control, are also considered key elements in the “11+”. The authors also acknowledge as essential to the success of the program, a higher rate of compliance and education of coaches, as they are considered essential in the implementation of the program (Al Attar et al. 2016).

Another systematic review and meta-analysis (Thorborg et al. 2017) revealed similar results as the one published by Al Attar et al. They referred that the FIFA 11 has no prevention effect, nevertheless the FIFA 11+ can reduce football injuries by 39% in recreational/subelite football players, confirming its injury preventing effect. They go further, revealing the percentage of reduction of the top four most prevalent football injuries. By these means, hamstring, hip or groin, knee and ankle injuries may be reduced by 60%, 41%, 48% and 32%, respectively. Considering compliance, the authors refer that less than 15% of the teams submitted to the FIFA 11+ in the RCTs that tested the effect of FIFA injury prevention programs achieved the minimum suggested weekly implementation of the program of two sessions per week during the season, suggesting higher benefits when the recommended dosage is fulfilled. The injury reduction observed with lower weekly frequencies that the recommended rate, may account for the injury reduction observed in our study, as during the 30 weeks of the study, the intervention teams were submitted to the FIFA 11+ during 20 weeks only.

Another systematic review on the FIFA 11+ (Sadigursky et al. 2017), also revealed a 30% reduction of injury risk for footballers. In the discussion, these authors reveal that amateur football players are more exposed to injuries compared to professional players due to the reduced technical abilities. The prevalence of the severity of injuries is also considered higher in amateurs compared to professionals (Van Beijsterveldt et al. 2015). However, the only futsal related study retrieved that analysed national teams and district teams by (Serrano et al. 2013), considered that the players in the national teams presented a higher rate of injury, most likely due the fact that these players had more exposure (more player hours). The researchers also consider that a higher age average may justify a higher injury rate of these players. We must point out that this study used retrospective data, which may make a difference, when comparing to results obtained in prospective studies.

To our best knowledge, in 2014 the first systematic review including the "11+" was published (Barengo et al. 2014). This review refers that in the FIFA 11+ studies, the injury reduction ranged between 30 and 70% benefiting male and female amateur football players. The authors consider the FIFA 11+ as an essential tool for injury reduction in amateur football, preventing the adverse effects that injuries instigate not only at a personal level but also in society. They also showed that this injury prevention program improves motor/neuromuscular performance. These motor and neuromuscular performance improvements are considered important for promoting the program amongst coaches (Barengo et al. 2014), as coaches are considered key elements in the implementation of the program and respective compliance (Soligard et al. 2010; Bizzini et al. 2011).

Motor and neuromuscular enhancement are associated to injury prevention in other injury prevention programs. A systematic review (Lauersen et al. 2014) refers that proprioceptive training and multiple exposure programs are considered to be effective in injury reduction, however, the results of the studies analysed were considerably heterogeneous. Likewise, in our study no changes were observed in joint position sense irrespectivelly of a significant decrease in the number and severity of injuries. The review also revealed that stretching, before or after exercise, did not show protective effect, however, the review only analysed, two studies, one envolving army recruits and the other, an internet-based study on the general population. However, an earlier systematic review in 2004 (Thacker et al. 2004), already revealed that stretching was not significantly associated with a reduction in total injuries of competitive or recreational athletes, recomending well-conducted RCT, to determine the role of stretching in sports. Nonetheless, of both reviews, futsal or indoor soccer was not contemplated. Even considering that literature has been reporting the lack of relation between flexibility and injury prevention, a considerable amount of futsal related studies that have been recently published, have still focused flexibility in futsal players (Ayala et al. 2010; Ayala et al. 2012; Cejudo et al. 2014; Cejudo et al. 2015) considering it to be an important parameter of performance (Ramos-Campo et al. 2016). An ideal level of flexibility is considered to be important in the prevention of soft tissue injuries, as in hamstring muscle injury (Ayala et al. 2011; Cejudo et al. 2014; Ramos-Campo et al. 2016).

The only study retrieved that tested the FIFA 11+ on futsal players revealed significant enhances on the performance parameters tested (Reis et al. 2013). This study tested young futsal players with an age average of 17.3 ± 0.7 years. The participants were tested for maximal quadriceps (Q) and hamstring (H) strength (isokinetic testing) with calculation of the functional ratio, jump performance (squat jump, countermovement jump), speed (5m and 30m sprint), agility (T-Test), technical skill (slalom-dribbling test), and balance performance (single-legged flamingo balance test). The selected performance and neuromuscular parameters chosen to be tested in this thesis were highly based on the previous futsal study referred, along with two other parameters that have already been tested by other authors. They where, jump performance (countermovement jump), speed (30m sprint), flexibility (sit-and-reach test), agility (T-Test), balance performance (single-legged static balance test and Y-balance Test), proprioception (active joint position sense) and isokinetic testing (quadriceps and hamstring concentric strength and hamstring eccentric strenght) with calculation of the conventional and functional ratios.

The first four parameters where considered in the first study submitted for publishing under the theme of performance parameters, *The FIFA 11+ does not alter physical performance of amateur futsal players*. The results published by (Reis et al. 2013), led to hope in the obsevation of similar enhancements. However, enhancements in performance were not actually expected by the researcher, as the interpretation of the FIFA 11+ manual, led to the belief it would be a warm-up that would adequately prepare the players for the following sport activity with the advantage that the specificity of the exercise drills would bring a protective effect for injury. However, some enhancements could be expected as the authors of the manual consider that injury prevention programs for football players must consider core strength, neuromuscular control, balance, eccentric training of the hamstrings, plyometrics and agility. The second part of the FIFA

11+ considers, six sets of exercises aiming at core and leg strength, balance, plyometrics and agility, with three levels of increasing difficulty. The accomplishment of the progressive levels of difficulty may leed us to expect that there may be significant gains with the exercise drills included in the program. However, the third and last part of the program, which concludes the warm-up, with 3 exercise drills, refers, for instance, that the 40 meter run, should be accomplished at *"(…) 75 – 80% of maximum pace and then jog the rest of the way..*" (Bizzini et al. 2011:64), requesting the execution of the exercise twice. The work load of the running may not be suficiente to expected gains in speed, for instance. However, there is always the call of attention for correct execution of this and all the other exercises contained in the program. The manual calls attention to the correction in the straightening of the upper body, the alignment of the hips, knees and feet, recalling consistantly not to let the knees buckle inwards. As the manual refers clearly, the use the adequate technique during all of the exercise drills is a key point in the program. The authors recommend the players to constantly keep in mind, the correction of body posture and optimal body control, with the necessary straight leg alignment, knee-over-toe position and soft landings. Considering the constant call of attention for body control, the lack of performance enhancements of the first study, were not fully unexpected.

The second study submitted, *Balance and proprioception responses to FIFA 11+ in amateur futsal players: short and long-term effects*, pretended to test the neuromuscular parameters of the participants of this study. The study by Reis et al. (Reis et al. 2013), showed enhancements in balance. Our aim was to test static balance with the force platform, which represents a gold standard for testing static balance (Mancini & Horak 2010) and to test dynamic balance with the Y-balance test, as it is a test simple field test that can assess dynamic balance and has also demonstrated predictive validity for injury risk in an athletic population (Shaffer et al. 2013). Our study did not reveal any significant enhancement for short and long-term effects for static balance. We expected balance enhancements, as balance enhancement is a key element of the FIFA 11+. The lack of significant results may associated to o lower than desired weekly frequency of FIFA 11+ sessions for these type of players. As Steffen et al. refers in their study, only the 78 players included in the intervention group with the highest adherence to the FIFA 11+ (average 2.2 sessions/week) revealed significant improvements in balance after adjustment for cluster, age group and playing level. The group with an average weekly FIFA 11+ sessions of (1.5 sessions/week), did not show significant gains (Steffen et al. 2013). The players tested in this study had an average exposure to the FIFA 11+ of 1.9 ± 0.1 sessions/week. A higher rate of exposure may be needed for these type of players.

In order to continue the body control assessment, we set to test for proprioception with active JPS. Again, no significant results were obtained, however, we realized that the average error of our players were lower, compared to the tested football players in the study used as methological reference for proproception testing (Magalhães et al. 2010). These results may assist to differentiate the specificity of futsal from football. No other studies including proprioceptive testing with active JPS of futsal players were found to substanciate this difference.

The third study submitted for publishing, *Effects of the FIFA 11+ on ankle evertors latency time and knee muscle strength in amateur futsal players*, continued in line with neuromuscular testing. This study analysed the reaction time of the leg muscles after sudden inversion of the ankle, with an electronic trapdoor mechanism arrangement, following an sEMG protocol of the peroneus brevis and peroneus longus. These results are in accordance with the study by (Dias et al. 2011) which tested the effects of a 4-week balance training program on the electromyographic latency of the ankle musculature in healthy 34 subjects (mean age: 19.5 years) with no history of ankle injury. No enhancements were found after intervention. The random opening of the trapdoor created the surprise effect of the opening of the trapdoor, however, the weight bearing was equally distributed on both feet, which may be considered different to real life sprain mechanism, as the ankle that sprains is normally fully loaded with the individuals weight. The lack of a plantar flexion component, as recommended by (Ha et al. 2015), would also bring the trap-door testing closer to real life situation as well.

The last outcome to be discussed here, belonging to the third study,is one of the most tested fitness component throughout the FIFA 11+ studies retrieved, strenght. In fact, strenght is an essential component to assess in sports activities. As the study by (Reis et al. 2013), showed enhancements in futsal players, we also expected to observe such gains, specifically in eccentric strenght, due to the specific eccentric training of the hamstrings of the FIFA 11+. The results after intervention did not show significant changes, however, at long-term analysis, significance was shown. Which may lead us to believe that some kind effect was created at this level.

The effects shown in some parameters 10 weeks after the intervention, may help to explain the significant reduction in injuries demonstrated. As shown in the summary of the main effects on performance and neuromuscular parameters of the FIFA 11+, in table 2 of the introduction, significance was not always present in the assessments executed, being the parameter strenght, the factor which in a consistant form, demonstrated enhancements in the studies observed.

CHAPTER 4

PRACTICAL IMPLICATIONS

PRACTICAL IMPLICATIONS

Although none of the performance parameters showed significant gains after 10 weeks of FIFA 11+ intervention, some significant gains were observed at long-term, considering that some kind of change occurred. We expected to observe performance enhancement for short-term effects as seen for football, as it would be an issue for motivation for coach and athlete adherence to the program. However, the significant results observed in overall injury prevention and severe injuries demonstrate the importance of the FIFA 11+ not only in football, but also in futsal, bringing clear benefits not only to the sports club which can count on the players for longer periods of playing time without injuries, as well as the benefits that injury prevention has on the player's overall health.

Considering the results obtained in this study and results obtained in the other futsal related study, we support the use of the FIFA 11+ as it may bring some long-term performance enhancements in amateur futsal players, but most importantly the decrease of injury incidence during the season. The significant results in decreasing the risk of injury in the players tested, alone, is a clear reason to adopt an injury prevention tool as the FIFA 11+ to individually benefit the player as well as the club.

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CHAPTER 5

CONCLUSIONS

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Literature is supportive regarding the effects of multiple exposure programs as the FIFA 11+ in injury reduction for football players. Our study is in line with literature for football players, showing that the FIFA 11+ demonstrates a significant reduction in overall injuries as well as in a reduction of the severity of injuries in amateur futsal players. However, when testing for main effects on physical performance and neuromuscular parameters of football players, literature is not so clear on which parameters lead the way for injury reduction, with an exception for strength. Our study showed a long-term effect in eccentric strength of the hamstrings in the FIFA 11+ group after baseline difference adjustments. The same occurred for static balance, however, no significant effects were observed for speed, agility, flexibility, jump performance, dynamic balance and evertors muscles latency time.

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Limitations / suggestions for future studies

The current trend in sports injury research are multi-intervention training programs. We can consider that exposure to extrinsic risk factors, such as environmental conditions or other players, can be somehow influenced, for instance, by not exposing players to extreme weather conditions and by promoting fair play between players. Some intrinsic risk factors may not be changeable, however, considerening factors such as physical fitness, muscular strength, motor abilities and sports specific skills are highly modifiable by traininig. The objective of the majority of injury prevention programs is to induce alterations on these risk factors with the enhancement of the athletes' intrinsic abilities. However, the diversity of components used in training interventions, make the interpretation of the results obtained rather complex (Leppänen et al. 2014). Assuming the nature of interventions that prevent sports injuries, the simultaneous blinding of the participants, the intervention stakeholders, and outcome assessors, and trying to avoid other co-interventions is extremely difficult. Current findings have shown that sports injuries can be prevented to some extent by means of injury prevention programs, yielding major benefits not only to an athlete's career but also to his health, avoiding major costs for society (Leppänen et al. 2014).

Future studies employing multi-intervention training programs should be conducted, with interventions created on the basis of evidence based single exposures, recommending further research into single exposures as in strength training, but also in proprioceptive training. Future studies should also encompass larger sample sizes, and should test for other proprioceptive modalities and strength parameters so that the protective effect on injury prevention can be clearer, allowing for the selection of the most relevant injury preventing exercise drills, so that programs may be easily integrated into training sessions, making compliance also more straightforward.

CHAPTER 6

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